Modern Concepts in Investigation of Aircraft Fatalities*

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Travel by aircraft has now become our chief mode of commercial transportation. According to figures recently released by the Civil Aeronautics Board (1), U. S. Airlines flew 26.3 billion passenger miles in 1957 compared with an estimated 25.2 billion passenger miles for buses and 21.6 billion passenger miles for railroads. Airline passenger has risen uninterruptedly since its inception and has made large gains within the past few years. Flying is safe. During 1957, an estimated 45 million persons were flown about 26.3 billion passenger miles with only 31 fatalities, or a fatality rate of 0.2 per 100 million passenger miles. (The National Safety Council estimates that automobile fatalities were at the rate of 2.7 per 100 million passenger miles.) In 1956, 41 million people were flown 23.2 billion passenger miles with 143 fatalities. The military experience similarly indicates that flying is safe, for only a minute number of flights end as an accident. For every 1000 flights flown by the U. S. Navy in 1955, 999.32 had no mishap; and during 1957 this figure was 999.44 per 1000 flights (2). The U. S. Air Force has experienced 999.79 landings in 1000 without an accident and 999.64 flying hours per 1000 without an accident.

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Nevertheless, with this steady decline in the total number of aircraft accidents, there has been an increase in the number of fatal aircraft accidents and an increase in the number of accidents for which a cause cannot be determined. For instance, the Air Force in 1922 experienced 506 major aircraft accidents per 100,000 flying hours and in 1955 there were only 17 major accidents per 100,000 flying hours. However, in the 1930's we averaged one fatal accident in every 13 major accidents, whereas, today, one out of every five major accidents results in a fatality indicating that about 20% of our accidents result in some death (3). The chief increase in the number of fatal accidents can be correlated with the high performance aircraft—flying higher and faster. Jet propelled aircraft are responsible for approximately two-thirds of the major aircraft accidents in the U. S. Air Force and for 60% of the pilot fatalities. During recent years, 14% of major aircraft accidents have been classified as "cause undetermined" and these are responsible for 40% of the fatal accidents, with the jet aircraft most frequently involved (4).

The foregoing data clearly indicate the magnitude of our problems and the ever-increasing need to consider the human factors in aircraft accidents as well as the engineering aspects with a correlation of the information obtained. It is now incumbent upon the medical profession to offer its assistance in the field of flight safety. Although the efforts of many medical specialties are required for such an endeavor, the field of Pathology is primarily concerned with the structural and functional changes in disease and, consequently, it is believed, offers great prospect in the coordination of flight safety information. The well established sub-specialty of Forensic Pathology together with all the related Forensic sciences have demonstrated their usefulness in establishing cause of death, sequence of events, etc.

Through the efforts of several interested flight surgeons and pathologists, a group of individuals met at the Armed Forces Institute of Pathology in March 1955 to discuss what could be done in the relatively neglected area which came to be termed "aviation pathology." So that the joint efforts of all could be coordinated, there was established the Joint Committee on Aviation Pathology by a Department of Defense

Directive (5) in November 1955 and the committee includes representatives from the U. S. Army, Navy and Air Force; the Royal Air Force; the Royal Navy; the Royal Canadian Air Force and the Armed Forces Institute of Pathology. The latter institution serves as repository for the records of the committee.

The work of the pathologist to be contributory must encompass more than the time-honored routine procedures and must include an acute awareness of the many factors involved in the "man-aircraft" relationship. The Armed Forces in a relatively short time have progressed rapidly in exploiting this new field of aviation pathology (6, 7, 8) and in attempting to utilize the knowledge and experience of their accident investigations. The military services have implemented service directives (9, 10) which facilitate the use of pathologists as an adjunct in aircraft accident investigations. A more recent Air Force Regulation recommends the procedures for the Medical Investigation of Aircraft Accident Fatalities and is supplemented by an outline form (11) for this purpose. The directives suggest appropriate procedures to be followed in such an examination and the steps briefly are as follows:

1. All major aircraft accidents in the military are investigated by an Aircraft Accident Investigation Board which has a minimum number of four members, which includes a pilot, a maintenance representative, an accident investigator, and a flight surgeon. Other appropriate members may be added as deemed necessary. The function of the pathologist will be primarily through the medical member of this Investigating Board.

2. The pathologist for such an aircraft accident investigation will be furnished in one of three different ways: (a) he may be the pathologist or a physician from a nearby base designated to perform the autopsy, (b) pathologists from the Air Force Histopathology Centers would be made available to go to the scene of the crash if mutually deemed necessary, and (c) in the event neither of the aforementioned is feasible, the services of a civilian pathologist are authorized for expediency.

3. Under ideal situations it would be the function of the pathologist to visit the site of the accident with the flight

surgeon in order to best obtain pertinent data particularly as it relates to protective equipment, environmental factors, and sequence of traumatic events. Full use of photographic facilities should be made at this time.

4. The body would then be removed for thorough post-mortem examination which would of necessity include gross photographs together with the use of x-rays in order to complete the permanent record. The Air Force form dealing with the post-mortem examination would serve as a guide to a thorough aircraft autopsy.

5. Upon completion of the gross autopsy a preliminary summary of the findings are given to the flight surgeon so that the Investigating Board can complete its initial report.

6. Suitable tissues for histopathologic and toxicologic studies, having been removed at the time of autopsy, are forwarded to the Armed Forces Institute of Pathology for completion.

7. Upon completion of the case, final copies of the autopsy protocol are forwarded to the base concerned, the pathologist, and to the Directorate of Flight Safety Research, USAF.

The gross autopsy form mentioned above has been implemented so that as much available information as possible can be obtained at the time of the initial autopsy. The first part of the form is concerned with pertinent administrative data which is followed by a listing of the major injuries incurred and statements regarding the circumstances of the accident. Condition of the wearing apparel and protective equipment is noted by checking the appropriate boxes. The condition and degree of exposure of the body is next determined which is followed by the external examination. A complete listing of the internal organs delineates many of the changes which might be encountered in their examination. Space is available for suitable biochemical and toxicological studies and it is necessary that the histopathology studies be appended as supplemental sheets.

During 1957, the Forensic and Aviation Pathology Section of the Armed Forces Institute of Pathology examined 536 aircraft accident fatalities including several on-the-spot investigations such as the Pan American Airlines accident last November in the Pacific Ocean and more recently the mid-air

collision over Los Angeles involving Air Force and Navy planes. Cases in Aviation Pathology are evaluated through a consideration of three major factors, (1) environmental conditions, (2) traumatic aspects and (3) pre-existing disease.

TABLE I

A. Environmental Factors
   1. Altitude—hypoxia, decompression
   2. Speed—"g" forces, spatial disorientation, windblast
   3. Toxins—carbon monoxide, fuels, odors
   4. Temperature—excessive heat, cold, humidity
   5. Noise—auditory effects, vibration
   6. Stress—pathology of terror

B. Traumatic Factors
   1. Protective equipment
   2. Escape
   3. Aircraft design

C. Pre-existing Disease

A. Environmental Factors

1. Altitude

a. Hypoxia

> A 25-year-old pilot was on a high altitude radar mission when he experienced an engine explosion and he decided to eject from his aircraft. The ejection was successful but the pilot was observed to open his parachute shortly thereafter at an altitude of approximately 35,000 feet. The pilot landed in a tree and when found 24 hours later was dead. He had only minimal external injuries resulting from parachute strap marks and landing in the tree. No internal cause of death could be found at autopsy.

Tissue was submitted to the Armed Forces Institute of Pathology for examination, and a determination for central nervous system lactic acid showed an elevated value indicating the possibility that the individual had experienced an acute ante mortem hypoxia episode. This elevated lactic acid value tended to confirm the supposed sequence of events, i. e.,—the opening shock of the parachute at such an altitude would be quite severe and of sufficient magnitude to dislodge

the pilot's oxygen supply exposing him to a rarefied atmosphere. The descent was at such a rate that he became hypoxic and was most probably dead upon landing in the tree. It is calculated that such a descent would require approximately 23 minutes to reach ground level, and about 11 minutes to descend from 35,000 feet to 10,000 feet.

Comment: One of the most important problems confronting Aviation Pathology is the post-mortem detection of acute ante mortem hypoxia or anoxia since histopathologic changes are of little or no value in its diagnosis. Through a joint effort of the Royal Canadian Air Force Institute of Aviation Medicine and the School of Aviation Medicine, USAF, a test on post-mortem tissues was devised which utilizes fresh frozen central nervous system tissue to measure the lactic acid concentration. This test has shown promise in laboratory animals and is currently routinely used at the Armed Forces Institute of Pathology.

Lactic acid levels over 200 mg.% in central nervous system tissue were found indicative of hypoxia although the elevated value did not differentiate the cause of the hypoxia. Therefore, a variety of conditions such as lack of oxygen from altitude, drowning, ingestion of certain drugs, shock, etc., may produce an elevated lactic acid value.

In 238 aircraft accident cases in which this test was routinely performed at the Armed Forces Institute of Pathology from October 1956 through January 1958, there were 10 instances in which a value over 200 mg. percentage was obtained. In one instance there was definite evidence that the elevation was due to altitude hypoxia, in one there was history of short survival in a shock state following the accident, in three cases hyperventilation seemed the most likely cause, in two instances drowning was responsible, in one case the administration of barbiturates to the hospitalized pilot after the accident, in one case strangulation was the most likely cause and in one the possibility was either hyperventilation or hypoxia.

b. Decompression Sickness

A 36-year-old pilot flying a T-33 jet trainer at 29,000 feet (cabin pressure 22,000 feet) coughed violently and complained of chest pain. He lost consciousness almost immediately. The

plane was successfully returned to base by the radar observer. The pilot was immediately taken to the hospital in a dyspneic and cyanotic condition. In spite of intensive therapy he expired about 12 hours after the initial onset of the symptoms.

The autopsy showed numerous fat emboli present in the lung, kidney and brain and there was a patent foramen ovale with an associated cardiac hypertrophy. An ischemic necrosis of the brain was observed. Fatty metamorphosis of the liver was present.

Comment: The post-mortem findings in this case were thought to be due to fat embolism secondary to decrompression sickness. Intense intravascular fat was found within the lungs and via a patent foramen ovale also within the brain and kidney. Many areas of cerebral ischemic necrosis were noted to be indistinguishable from those due to aero-embolism. The pathogenesis of this condition being postulated as follows: adipose tissue contains a supersaturation of gas, with bubble formation occurring upon decompression which is followed by rupture of the cells and release of their fat and gas into the vascular system.

The simple explanation of embolism may actually reflect a more fundamental change brought about by this condition and is an area in which considerable more investigation is needed. A study of the pathological findings in 14 cases of death due to in-flight decompression sickness studied by the Royal Air Force Institute of Aviation Medicine and the Armed Forces Institute of Pathology has brought this problem into sharper focus and dictates the need for further experimental studies of this phenomenon.

2. Speed

a. Spatial Disorientation

The pilot of a F-100 jet fighter was the leader of a flight of three aircraft. At approximately 2500 feet altitude, and in cloud layers, the pilot radioed that he had lost his gyro. Shortly afterwards the No. 3 man in the flight observed his aircraft entering a diving turn to the right and disappear. The pilot was killed and the aircraft destroyed.

Comment: Spatial disorientation, or vertigo, is more difficult to prove because it has no relation to altitude or failures of equipment, and as far as is known has no demonstrable

pathologic lesion. It is significant to note, however, that inner ears are seldom examined in such instances. Their removal should be routine in every aircraft accident fatality. The occult nature of spatial disorientation taxes the ingenuity of all aircraft accident investigators, but the most frequently associated pattern is as follows: The aircraft which were involved and were about to be destroyed were always jet fighters or interceptors. The pilots were usually young, at least inexperienced. The state of flight was usually in the landing or approach pattern, but sometimes shortly after takeoff. The altitude was relatively low, usually about 2000 feet. The aircraft speed was usually about 350 knots. The aircraft was often in a procedural turn or doing flying requiring frequent change of visual reference. Instrument flying conditions prevailed with minimum visibility, or it was a black, black night. The pilot was requested to change radio channels or modes, or was in a position where routine channel changes should have been made. After the pilot had been requested to change channels, he replied affirmatively; or, if it were a rountine change, he may have announced that he was changing channels. Almost immediately thereafter, the aircraft struck the ground with terrific velocity and oftentimes in a near-vertical altitude. Further investigation revealed that the radio channel selector was set far to the rear of the right console in practically all aircraft involved. This made it necessary for the pilot to change hands on the stick and turn his head down and to the right. Therefore, he not only lost monitorship of his essential instruments, but was in an ideal position to establish the most vicious form of vertigo caused by coriolis force (4).

b. Windblast—In an attempt to prevent any windblast injuries resulting from bailout from a high speed aircraft, experiments have been conducted utilizing primates as subjects on sled track runs using speeds approximately 2 Mach or twice the speed of sound. The exposed skin surface showed various changes including separation of the superficial epidermis into a distinct layer, compression of the remaining epidermis into a thin leatherly structure, loss of hair and focal hemorrhages. The windblast was accompanied by a temperature between 300°–320°F. From this and other studies

the importance of protective equipment and clothing design have assumed major roles in the prevention of injuries to flying personnel.

3. Toxins

Much work has been devoted to the environmental problem of toxins, especially that of carbon monoxide. Although carbon monoxide has been one of the more commonly incriminated toxins associated with aircraft accidents, a review of the records of the Directorate of Flight Safety Research, USAF, reveals that cases showing elevated carbon monoxide values were usually associated with viability and a history of fire, either in-flight or following ground impact. Therefore, the most practical value placed on a post-mortem carbon monoxide level is in establishing the sequence of events, i. e., was the individual alive or dead at the time fire ensued?

The Armed Forces Institute of Pathology routinely analyzes fresh frozen tissues submitted from aircraft accident fatalities for carbon monoxide and already has completed this examination in 189 cases. Since blood is not frequently available, our laboratory utilizes bloody extracts from tissues and the analysis is performed as for blood. The results are reported as per cent carboxyhemoglobin saturation as for blood, and levels less than 10% are considered insignificant, heavy smokers may attain values as high as 8%. In 13 cases this method has demonstrated an elevation (over 10% carbon monoxide saturation), all of which have been in conjunction with fire, usually following impact. This finding of significant amounts of carbon monoxide is indicative of survival following the onset of fire and such information is at times of inestimable value to the aircraft accident investigators.

Frozen tissues are routinely examined for the presence of alcohol since a prominent percentage of the fatalities show varying degrees of fatty metamorphosis of the liver. From October 1956, the Aviation Toxicology Laboratory has examined 318 cases. In only one instance have the results indicated ethyl alcohol.

All fresh frozen tissue is held in the laboratory in the frozen state for at least 30 days so that additional procedures may be performed as indicated. The Aviation Toxicology Laboratory is devoting considerable effort to methodology for the

determination of therapeutic amounts of drugs in tissues of aircraft accident fatalities. Customarily, the toxicologist deals with lethal amounts of drugs, usually in relatively large quantities, but the current problem facing aviation pathologists is the detection of minute amounts of drugs, for the most part taken without medical advice. A procedure employing paper ionophoresis has proven satisfactory for the detection of such drugs as tranquilizers, antihistamines, barbiturates, alkaloids and those taken for the prevention of motion sickness. This work is being performed by Dr. Leo Goldbaum, who is in charge of our toxicology laboratory, and he has reported his results at this meeting. It is anticipated that future activities at the Armed Forces Institute of Pathology will include increasing research in aviation toxicology.

Toxin Case: A routine commercial passenger flight with thirty-six passengers and a crew of eight departed from San Francisco bound for Tokyo with stops at Honolulu and Wake Island. The flight weather forecast was generally good with visual flight rules prevailing after departure from San Francisco. The flight was cleared for a cruising altitude of 10,000 feet and an air speed of 226 knots. According to the weight and balance manifest, the aircraft was loaded in accordance with prescribed practices. Position reports were scheduled at four minutes each hour and "operations normal" reports at 34 minutes past each hour. These routine position and "operations normal" reports were received on schedule indicating normal flight progress and fuel consumption. Shortly after the aircraft passed over the ocean weather station vessel November, the half-way point to Honolulu, a normal position report was given at four minutes past the hour, which was the last intelligible message received from the aircraft. The weather at the ocean station vessel November and in the general area of the accident was good for flying.

From the above information it is evident that the emergency was sudden in nature. It was the general consensus that the emergency either disrupted communications or was of such an acute nature that it precluded sending a message. Another alternative to be considered was that of sudden crew incapacitation might be due to a variety of conditions including pre-existing disease, violence, presence of toxic substances, etc. A check of the cargo manifest showed several potentially toxic substances.

One significant item of cargo consisted of 1¼ pounds of crystalline sodium sulfide which was in the forward baggage compartment. This crystalline sodium sulfide was capable of liberating 5.5 cubic feet of noxious hydrogen sulfide gas. Although hydrogen sulfide has a characteristic "rotten egg" odor, in relatively large concentrations it is reported to rapidly paralyze the olfactory nerve, produce incapacitation and at times sudden death.

The radioactive cargo consisted of two substances, radioactive Cesium 137 and radioactive Barium 133. Chemically these substances had the composition of cesium chloride and barium sulfate. Both emit gamma and beta irradiation. They were sealed in a metal container which in turn was properly packaged and labeled. This container was stowed in the forward baggage compartment.

Another cargo item stored in the forward baggage compartment consisted of several drums labled "organic medicinal chemicals." Upon inquiry, these were found to contain a tranquilizer in powder form known as Ectylurea. This substance is an unsaturated uriide and a carbamate-like drug. The material is considered inert and insoluble. The flash point is 180°–190°C.

A large quantity of film was also stowed in the forward baggage compartment and is presumed to be of the safety type. This film does not combust, but is capable of producing carbon monoxide when exposed to intense fire.

An important feature regarding the material stowed in the forward baggage compartment is the flow of cabin ventilation. It is our understanding that in flight, the airflow tendency is such that odors from the forward baggage compartment are first detected in the cockpit area, thus any noxious substance produced in the forward baggage compartment would be first apparent in the crew compartment.

Nineteen bodies were recovered from the accident and autopsies were performed on all. The tissues have been examined for possible toxicologic substances. No evidence of any volatile poisons or drugs could be detected in the pilot, purser, stewardess, or selected passengers. Examination for alcohol was performed, but due to the formation of alcohol in association with post-mortem decomposition, no definitive

interpretation could be made regarding the ante-mortem presence of alcohol. Careful studies were performed for the presence of hydrogen sulfide, particularly in the case of the pilot and purser. A qualitative and quantitative test using lead acetate was employed to demonstrate hydrogen sulfide and the results obtained were in keeping with amounts of hydrogen sulfide liberated solely as the result of post-mortem decomposition.

Examination of blood and tissue samples for carbon monoxide saturation have shown elevated values in many of the bodies, some of whom had immediate lethal lesions. The determinations have been performed by four different laboratories using four separate means of determination including gas chromatography which is extremely specific and sensitive. Yet the interpretation of these results is difficult since the samples showed marked post-mortem decomposition. Utilizing rough screening experiments, we have reason to believe that extreme post-mortem decomposition of a specimen, particularly while in the body, may yield false positive results. Until this problem is resolved the significance of the results cannot be accurately assessed.

All bodies were carefully examined for any presence of radiation, and none was found.

4. Temperature

a. Exposure to Cold

> During severe winter weather, the pilot of a jet trainer experienced mechanical difficulty at 26,000 feet altitude. By radar he was over water on a course heading back to the originating base when he ejected from the aircraft. The search was fruitless during the night hours and the following afternoon his body was found at the shore. From an evaluation of the personal equipment, it was apparent that he had successfully completed the ejection and that his life vest and dinghy were inflated. The reconstructed sequence supposes that the pilot, wearing summer type clothing, waded through marshes waist deep for approximately 1½ miles and then collapsed on the beach.

Comment: In spite of well regulated air-conditioning systems, the present day pilot must be prepared to encounter extremes in temperatures within a single flight, summer or winter. The severe cold experienced at high altitudes has

been sufficient to produce severe cold thermal injuries on bail-out cases and it becomes necessary for survival that the pilot be furnished with adequate personal equipment and even more important that he use the apparel. The pathologist investigating any aircraft accident should determine what effect the personal equipment had in the survival of the pilot.

B. Traumatic Factors

The second broad group of pathologic changes studied in aircraft accident fatalities centers about the traumatic aspects In many instances these overshadow other considerations to such an extent that one is sometimes asked, "Why do an autopsy when the cause of death is so obvious?" In aircraft accident fatalities, however, it is not enough to state the immediate cause of death, such as crushed chest or broken neck or injuries-multiple, extreme. It is necessary to pin point the cause of the injury which resulted in the lesions causing death. For instance, if the cause of the accident is established, such as a mechanical failure of the plane, the prosector should devote the majority of his efforts to determining how the crew member sustained his injuries by relating them to known mechanisms of the accident. From this the architects and engineers may learn what can be done to prevent these injuries. This is chiefly a process of deductive reasoning on the part of the prosector, where much study can be devoted to a narrow field.

On the other hand, if the cause of the accident is unknown the prosector should gain as much information about the circumstances of the accident as possible, before he starts the autopsy. Without it much time and effort may be wasted in irrelevant work. This autopsy should be a careful and meticulous study employing an inductive reasoning approach and utilizing as many adjunctive studies as possible. An essential part of all gross autopsies performed on aircraft accident fatalities is a detailed examination of the condition of the clothing and protective equipment.

The correct interpretation of certain pathologic findings will frequently lead to invaluable clues in unraveling the sequence of traumatic events. When examining the heart and lungs for lacerations, it is important to note if the lacera-

tions were made by fractured ribs and if so, by which ones. If there is a laceration of the aorta, was it due to a fractured bone, or was it the result of a sudden deceleration, each of which show characteristic lesions? In a laceration of the liver, for instance, it would be helpful to know if such was due to rib fractures or a crushing injury impinging the liver against the vertebral column. Many times the question of viability during a fire is raised and the anatomical demonstration of soot, either gross or microscopically, within the respiratory tract, especially the lungs, indicates that the crew member inhaled smoke, and thus was alive in the presence of a fire. It is well to remember that heat alone may produce false epidural hemorrhage and artefactitious fractures particularly of the skull.

Traumatic Case 1: Shortly after midnight a B-57 jet bomber was cleared for a ground control approach landing due to the low visibility. A rapid penetration was made from approximately 20,000 feet into the cloud layer and approximately 2½ miles from the airport. On the final approach the ground control advisor told the pilot he was high on the glide path. At ¾ mile out on final approach the aircraft was still observed to be high on the glide and the pilot was ordered to execute a missed approach landing and "go around." Personnel at base operations observed the aircraft to break from the cloud layer, and the pilot applied full power to the aircraft. The plane veered to the left contacting trees approximately ½ mile to the left far end of the runway producing aircraft disintegration and death to the pilot and co-pilot. The bomber veered to the left, struck a tree, took a tremendous bounce, struck another tree and then started disintegrating. The remains of the pilot and the co-pilot, the canopy and portions of the aircraft continued to plow through the trees. The pilot sustained extensive skull fractures, and an extensive eviscerating laceration involving the right chest and numerous fractures.

One might say the cause of death was quite obvious without any further examination, and at autopsy the heart demonstrated a prominent laceration of the right ventricle, but on closer inspection the finding in the arch of the aorta just distal to the subclavian artery was most interesting. Traumatic rupture of the aorta, at that point just beyond where the ductus arteriosus enters, is a characteristic lesion seen in abrupt deceleration. What then does this mean? This

indicates that the individual when he struck the first tree sustained an intense abrupt deceleration which was of sufficient magnitude to rupture the aorta, and this lesion was his single lethal lesion. It was not until he struck the second tree that these previously mentioned lesions occurred, all of which were post-mortem in nature. The real cause of death was the ruptured aorta which would not have been demonstrated without a thorough autopsy.

The co-pilot sustained fragmentation of the body and showed extensive burning. It became important to determine whether or not the burns were ante-mortem or post-mortem. No blood sample was readily available. Examination of the soft tissues failed to reveal any good source for blood; however, when the sternum was opened it readily showed a marked amount of bright red blood which upon eluting presented a very satisfactory specimen. The determination for carbon monoxide was negative thus indicating the fire started after the co-pilot's death.

Examination of the portions of the aircraft presented causes of some of the pilot and co-pilot lesions. The canopy of the aircraft had marked distortion of the cross bar which coincided with the imprint of the back of the pilot's head and changes of the pilot's hard helmet. The co-pilot's seat was literally divided by the impact force which tended to indicate that the co-pilot was in the seat at the time the extensive crushing and shearing forces occurred.

Traumatic Case No. 2: A constellation type aircraft was on practice instrument landing flight and was being followed by radar. The first approach to the field was off course, both by altitude and direction. The second approach was on course but at a low altitude. At a distance of approximately two miles from the landing strip the plane was spotted by radar at 400 feet altitude. The tower waved off the aircraft because the plane continued to come in at such a low altitude. Several witnesses reported an increase in noise level attributing it to the application of power. The plane passed over a group of houses then struck a group of trees approximately 1½ miles from the touch down end of the landing strip. The left wing struck first and then the plane described an arch of 180° against an embankment. The bodies of nine people were found to the left of the wreckage lying on a road. A fire followed the impact and the plane burned for two hours.

One of the most important questions raised by the Accident Investigating Board concerned which of the three pilots aboard was actually flying the aircraft. Two of the pilots were quite experienced, the other relatively inexperienced. Unfortunately, a commonly committed error was made in that all of the bodies were removed from the aircraft accident site prior to the arrival of the flight surgeon. It was necessary to reconstruct the man-aircraft relationship to decide which pilot was actually in control of the aircraft. One of the more experienced pilots had burns on the right side of the body which corresponded to the right sided burning of the right pilot's seat. The individual thought to be in the left pilot's seat had seat belt marks corresponding to the cinched seat belt found on the left pilot's seat. It was then assumed that the two more experienced pilots were in control of the aircraft at the time. The less experienced pilot had injuries which corresponded to other fatal crew members found in the passenger compartment. The exact position of three other crew members could be outlined by the type of injuries they sustained. Members in the passenger compartment were subjected to thermal burns of greater magnitude than those in other portions of the aircraft. In addition, those in the passenger compartment had been subjected to large quantities of gasoline, one of whom literally drowned in gasoline.

On occasion, ultra-violet light may be helpful in establishing sequence of events. Fuels and oils have a characteristic fluorescence which is either natural or has been intentionally added to the material. Some natural substances such as tissues emit a characteristic fluorescence when exposed to ultra-violet light; for instance, blood is a royal purple color, cartilage blue-white, etc. In a recent case, the lung presented a yellow-green fluorescence. The material was fuel to which fluorescence had been added for easy differentiation. Although its presence was of no great importance to the case in question, the usefulness of such an examination is obvious. Another example of its use was in conjunction with the recent Pan American Airways accident in the Pacific Ocean. A wooden portion of bulkhead was partially burned and there was a brilliant yellow-green fluorescence at the junction between the burned and unburned wood. Careful reconstruction

showed this most probably due to fuel burning on the water with the submerged wood intact.

Much valuable information can accrue from an evaluation of passenger fatalities and injuries. In a recent article (12) a study on injuries in relation to the seat facing indicated that in survivable transport type aircraft accidents, rearward facing seats afforded a greater degree of protection to the passengers than did forward facing seats. There were no fatalities among 286 rearward facing seat occupants and only two with major injuries, whereas in comparable accidents involving 914 forward facing seat occupants, 13 sustained fatal injury and 39 major injury. This data has brought about considerable discussion points to the need for future intensive investigation of the passengers involved in aircraft accidents.

C. Pre-existing Disease

In the realm of pre-existing disease the presence of coronary sclerosis offers much room for speculation. A coronary attack in the pilot of a single place aircraft could well result in another unexplained aircraft accident. Predictions of the importance of coronary sclerosis in pilots had been made by Benson (13) and White (14) in 1937 and 1940. Although many of the coronary arteries examined in deceased pilots show moderate to marked coronary sclerosis, the following three cases present the problem the pathologist faces in evaluating coronary arteries from autopsy material and illustrate the necessity for a cautious interpretation of the significance of such findings.

> *Pre-existing Disease Case No. 1.* A 27-year-old pilot was on a routine ferrying mission in an F-102 jet fighter aircraft. Approximately one hour after departure, at an altitude of 40,000 feet, he experienced a flame out due to fuel starvation. A local base was alerted to the emergency and approximately three minutes later he advised the tower that he was five miles north of the field at 4,000 feet. He continued his emergency landing procedure, lowered his gear at 2,000 feet and was normally communicating with the tower. The plane stalled and crashed into a wooded swamp.

There had been no previous history of cardiac symptomatology though the autopsy showed a severe arteriosclerosis.

In this case there was no evidence to indicate that coronary disease had played any role in the accident; however, if the facts were not known, pilot failure through coronary insufficiency might well have been incriminated as the case.

Pre-existing Disease Case No. 2. The pilot, aged 36, and the co-pilot, aged 32, were on a routine cross country flight in a T-33 jet trainer aircraft. They were flying at an altitude of 37,000 feet with a cabin pressurization of 25,000 feet. The aircraft contacted the ground with tremendous impact force producing instant death to both crewmen. Intensive study of the accident failed to reveal a mechanical cause for the accident and an oxygen system failure with hypoxia was suspected. Lactic acid studies did not support the contention that hypoxia existed, but since there was a delay in procuring the central nervous system tissue samples there may be some question concerning the validity of the results.

Although neither men had a history of previous heart disease, it is interesting to note that both had an advanced coronary sclerosis with a restriction of the coronary lumen. There is a possibility that coronary insufficiency and/or lack of oxygen may have contributed to this accident.

Pre-existing Disease Case No. 3. A 28-year-old pilot of an F-86 jet fighter aircraft was the No. 2 man of a two ship flight on a practice scramble mission. A C-47 type aircraft passing in the vicinity was contacted then granted permission for the fighters to make an identification pass on the aircraft. Following the pass, the C-47 crew noted the No. 2 F-86 aircraft to pull up on the right wing, hesitate for a few seconds, roll over on its back and crash. Although there was no previous history of cardiac abnormality, the myocardium showed fibrosis which indicated previous episodes of coronary insufficiency. In this case, the question can be raised, "Was the accident the result of a coronary attack?"

Other types of pre-existing disease have been responsible for sudden incapacitation of a crew member with or without a resultant accident. Nelson and Haymaker (15) have described three cases of sudden incapacitation due to colloid cyst of the third ventricle. An astrocytoma was responsible for the first onset of unconsciousness in a pilot which would have resulted in an accident had a co-pilot not been present. A sudden crew incapacitation has occurred as the result of sickle cell anemia. Certainly any disease that can produce

sudden death at ground level can similarly produce sudden death at altitude; among items of unsuspected pre-existing disease which have been encountered include such items as: carcinoid of the bowel, rheumatic heart disease, gastric ulcer, incarcerated omental hernia, viral disease of lung, patent foramen ovale heart, etc.

Summary

From the foregoing it is now apparent that death or incapacitation of the crew may actually cause an accident rather than being only the result of the accident; therefore, a complete and thorough medical investigation of aircraft accident fatalities must be instituted. This study should include a correlation of injuries sustained with the mechanical aspects of the accident for the prevention of future injuries. A careful consideration must be given to environmental factors and pre-existing disease as the cause of air accidents. The military services have established a program for the investigation of aircraft accidents to include an intensive medical examination utilizing the practices of forensic sciences. Due to the ubiquitous nature of aircraft accidents, both civilian and military, members of the American Academy of Forensic Sciences and similar groups will be actively participating in these examinations. It is obvious that such a program cannot succeed nor be productive without the cooperation of all groups concerned.

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The Fractured Hip in Its Relation to Death: A Medicolegal Evaluation*

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The role of the fractured hip in its relation to death is a problem which has not been adequately studied. Yet, this type of case comprises the largest category reported to a Medical Examiner or other legally designated authority because of a traumatic factor. Because of the usual absence of criminal charges, the age, the objection of families and the reluctance of forensic pathologists to increase their work load with problems of a civil nature, the cause of death in the majority of these cases has been certified without autopsy on the basis of clinical diagnoses. The reliability of the latter proves to be apocryphal.

This study was made to define a pathologic physiologic basis for delineating those cases in which death could be directly attributable to the fracture (accidental means) from those in which the fracture aggravated pre-existing disease (contributory) or in which the fracture was an incidental, unrelated finding.

Material

In Philadelphia any death in which there may be a factor contributory to death other than the usual progress of a

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natural disease process, whether that factor be the result of an act of God, nature, man, machine, physician, surgeon or anesthetist, is reportable to the Office of Medical Examiner.

During the first two years of the Medical Examiner System in Philadelphia, from February 1, 1956, through January 31, 1958, 582 cases of fractured hips were reported constituting 5.4% of the total 10,791 cases. This group exceeded all other groups of non-natural cases: deaths associated with operative and anesthetic procedures—456; suicides—353; vehicular accidents—328; homicides—322.

In 280 cases the right hip was fractured and in 301 cases the left hip. Both hips were involved in one instance. Previous hip fractures had occurred in 18 cases: the opposite hip in 11 cases and the same hip in 7 cases. In 9 cases there was also an incidental fracture of an upper extremity, but in no other cases were there other significant injuries. No breakdown was made between extracapsular (trochanteric) and intracapsular fractures.

The series also includes 13 cases of pathologic fractures of the hip due to metastatic tumor.

Autopsies were performed in 288 cases including 168 white females, 10 non-white females, 103 white males and 7 non-white males. Sixty autopsies were performed by the author and 228 by other pathologists. Because of increased interest as many autopsies were performed from August 1, 1957, through January 31, 1958, as in the previous 18 months of the study.

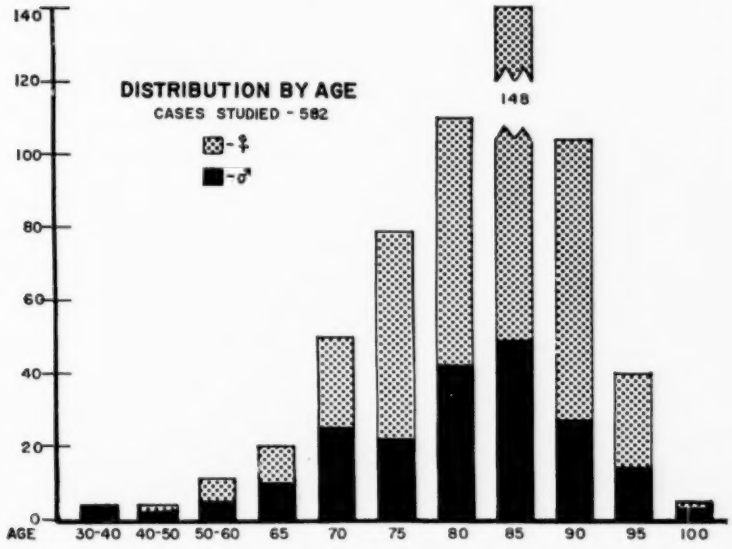
Results and Interpretation

The cases ranged on a month-to-month basis from 3.9% to 7% of the total cases reported during each monthly period. The largest number and proportion of deaths occurred during the months of January and May, and the smallest number and proportion during the month of November, but with erratic totals during the two-year period. A tabulation of the months of injury showed a slightly greater proportion during the winter months as reported by others (1, 2). There was no significant statistical correlation of injury with the day of the week except for a possible increase on Wednesday. Although injuries occurred throughout the twenty-four hours

of the day, the time of injury was consistent with the more active hours.

The age and sex distribution are tabulated in Figure 1. The over-all average age at the time of death was 78.2 years with an average life expectancy in Philadelphia during this period of 66.7 years (3). The average age was thus 11.5 years greater than the average life expectancy and equal to the remaining life expectancy of individuals who had already attained the average life expectancy. The reported ratio of 4 females to 1 male (4) is not borne out by this study in which the ratio of female to male was 1.9. This sharply contrasts, however, to the usual proportion of total deaths from all causes reported to the Office of Medical Examiner of which males constitute 75%.

FIGURE 1

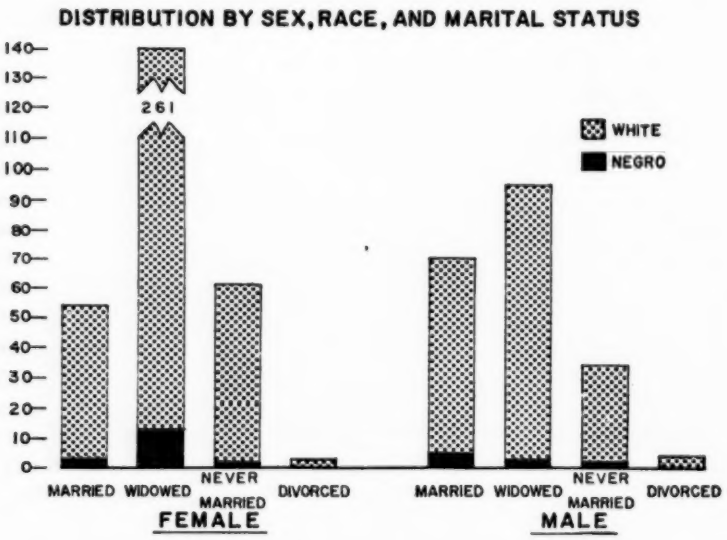


Although the estimated non-white population of Philadelphia is 22.4%, the non-white population constituted only 4.8% of the total cases of fractured hips. The reason for this

low number of non-whites is not apparent. This may be due to an increasing proportion of young non-whites migrating to this area from elsewhere.

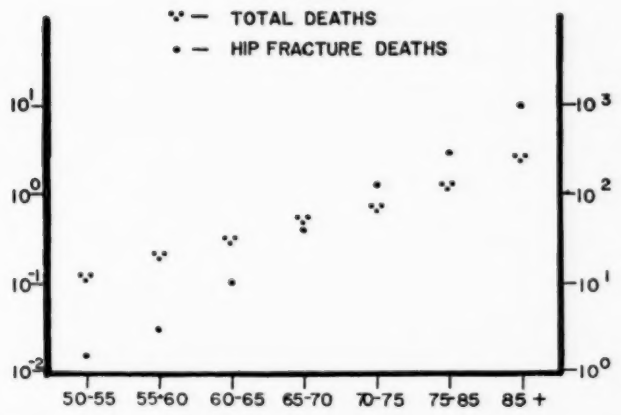
The distribution by race, sex and marital status are tabulated in Figure 2. Whereas more than one-third of the white males were married, only 14% of the white females were married, with the white widowed females contributing 43% of the total case load. The reason for this is again not apparent.

FIGURE 2



In Figure 3 the logarithms of the proportions of deaths with hip fractures per 1,000 population are compared with the logarithms of the death rate per 1,000 showing a striking increase in the older age groups as noted by others (1) with a slope more than twice that of the death rate. The logarithms of the proportion of deaths with fractured hips and the total number of deaths for each age group of the population are compared in Figure 4. Although there is a marked increment in the proportion in the 65–70 years age group, the slope in the elderly fairly closely parallels the death rate.

FIGURE 3



INCIDENCE of HIP FRACTURE DEATHS to TOTAL DEATHS

PER 1000 POPULATION PER AGE GROUP

FIGURE 4

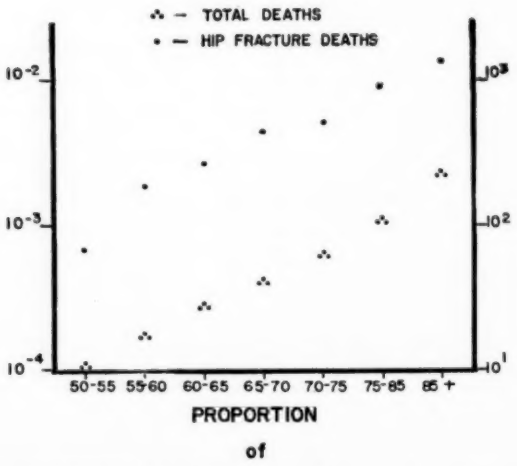
PROPORTION of HIP FRACTURE DEATHS to TOTAL DEATHS

A natural manner of death had been designated in only 122 cases. Re-evaluation of the remaining cases indicated

that in an additional equal number, previously considered as accident, there was probably no relationship between the injury and death, and the manner of death should be reassigned as natural. This 40% proportion of the total cases is compared logarithmically in Figure 5 to the total number of deaths for each age group. The slopes show a striking parallel. The absence of a statistical effect of the fractured hip on mortality in the older age group has previously been noted (5).

These figures illustrate the fact that in a large proportion of cases the fracture is not a significant factor in contributing to death.

FIGURE 5



The mode of injury is tabulated in Figure 6. Although the majority occurred as expected by a fall from the erect position, a considerable number fell from a sitting or reclining position. Many of the injuries were stated to have been incurred going to, while in, or leaving the bathroom. Especially noteworthy in the tabulation of the place of injury in Figure 7 is that in more than one-fourth of the cases the injuries were sustained in hospitals or nursing homes.

FIGURE 6

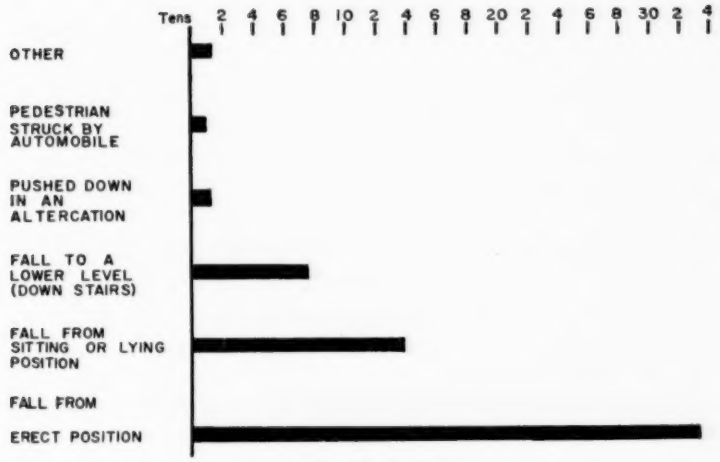
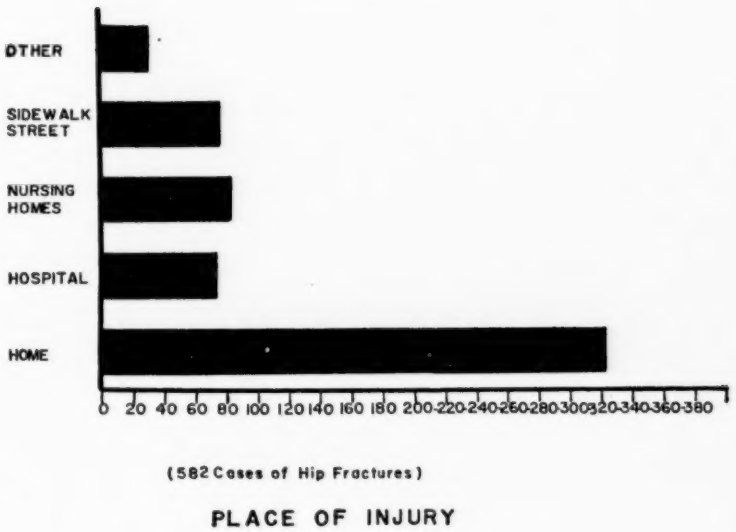
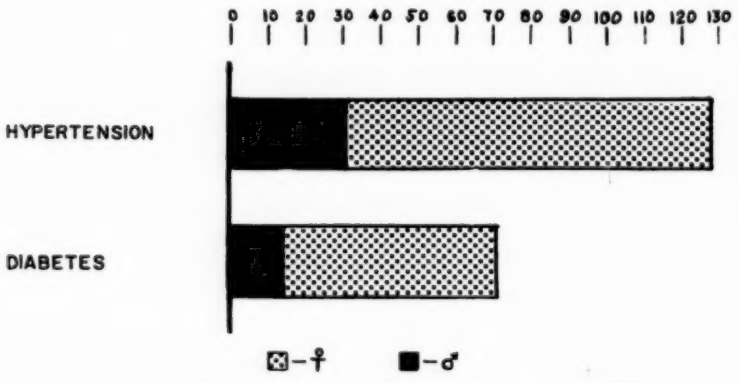

Tens 2 4 6 8 10 2 4 6 8 20 2 4 6 8 30 2 4
OTHER
PEDESTRIAN STRUCK BY AUTOMOBILE
PUSHED DOWN IN AN ALTERCATION
FALL TO A LOWER LEVEL (DOWN STAIRS)
FALL FROM SITTING OR LYING POSITION
FALL FROM ERECT POSITION
MODE OF INJURY
(582 CASES OF HIP FRACTURE)

FIGURE 7


OTHER
SIDEWALK STREET
NURSING HOMES
HOSPITAL
HOME
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380
(582 Cases of Hip Fractures)
PLACE OF INJURY

The incidences of known hypertension and diabetes mellitus are tabulated in Figure 8. At least 22% were known hypertensives; 12% had known diabetes mellitus. The incidence of diabetes mellitus in females was more than three times that reported by Kenney (6) and greatly in excess of the usual average of one out of forty-five of the general population in the older age group. The incidence of 7% in the males is also several times the usual occurrence of one out of seventy in the general population in the elderly age group.

FIGURE 8



INCIDENCE of KNOWN HYPERTENSION and DIABETES

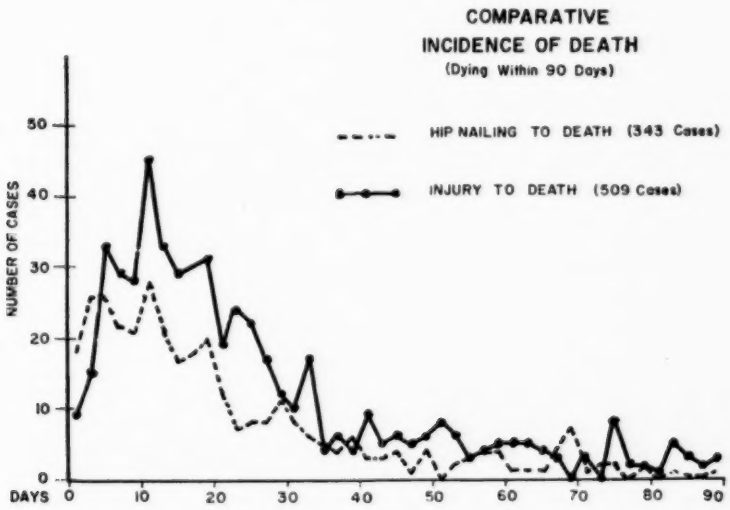
TOTAL CASES - 582 (379 ♀, 203 ♂)

In Figure 9, the duration from the time of injury to death is compared with the duration of time from surgery to death in those cases dying within ninety days. One-fifth of the cases died within ten days following the injury, 62% within thirty days and 87% within ninety days; 30% of the cases in which hip nailing was done died within ten days and 70% within thirty days.

Although the survival rates are not available, the parallel suggests that in the majority of cases surgical treatment plays relatively little part in affecting the mortality rate.

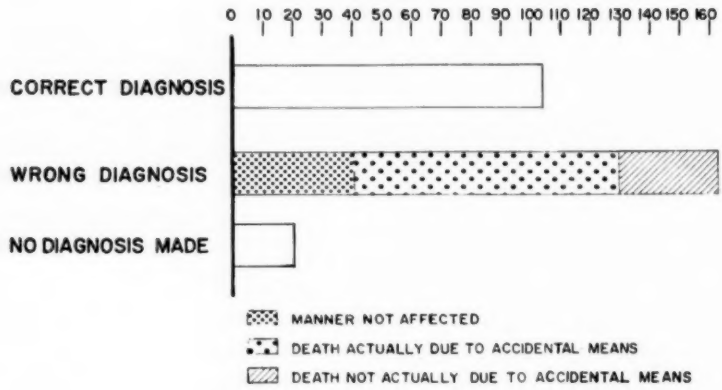
Death certificates in one-half the cases were signed without autopsy. In more than a third of the cases in which no autopsy was performed, the immediate cause of death stated on the death certificate was different from the clinical diagnosis. In one-third of these cases, death was attributed to pneumonia and in more than a third to heart disease. These figures are considered to be questionable when compared to the datum from autopsies.

FIGURE 9



A comparison of the clinical versus pathologic diagnosis is made in Figure 10. Autopsy demonstrated the clinical diagnosis to be wrong in 61% of the cases in which a clinical diagnosis had been made. In 31% the pathologic cause of death could be directly attributable to the fracture in contrast to an independent natural disease diagnosed clinically. In 11% of the total cases death at autopsy was found to be due to an independent disease in contrast to a clinical diagnosis directly attributable to the fracture. Exclusive of the cases in which no differential diagnosis was made, a total error greater than 42% would have been made if the cause and

FIGURE 10


0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
CORRECT DIAGNOSIS
WRONG DIAGNOSIS
NO DIAGNOSIS MADE
MANNER NOT AFFECTED
DEATH ACTUALLY DUE TO ACCIDENTAL MEANS
DEATH NOT ACTUALLY DUE TO ACCIDENTAL MEANS

(288 AUTOPSIES)
ACCURACY of CLINICAL DIAGNOSIS and EFFECT on MANNER

manner of death had been stated on the basis of the clinical diagnosis only. It is doubtful that the clinical acumen of physicians in Philadelphia is significantly inferior to that of physicians in other parts of the country.

The inability to determine accurately the relationship of an injury to death in the absence of complete autopsy is strikingly emphasized.

The most common anatomically proved causes of death were pneumonia and pulmonary embolism which constituted 60% of the cases. This contrasts sharply to the cases in which no autopsy was performed in which in only 37% was death ascribed to these two causes. In nearly 70% of the total series, the cause of death as determined by autopsy differed from the clinical diagnoses.

A further analysis of the accuracy of the clinical diagnosis is made in Figure 11. Of the 69 cases in which death was due to massive pulmonary embolism, only 12 were clinically diagnosed correctly, even though the diagnosis of pulmonary embolism was made clinically in 31 cases. The ante-mortem diagnosis of pneumonia was most frequently confirmed, but in one-third of the cases death was actually due to massive pulmonary embolism or coronary artery disease. Cerebral vas-

FIGURE 11

CLINICAL Vs. PATHOLOGIC DIAGNOSIS
as to the
Immediate Cause of Death

(288 AUTOPSIES)	CLINICAL DIAGNOSIS						
PATHOLOGIC DIAGNOSIS	(a)	(b)	(c)	(d)	(e)	(f)	TOTAL
(a) PULMONARY EMBOLUS	12	0	24	12	7	14	69
(b) FAT EMBOLISM	0	0	0	0	0	4	4
(c) HEART DISEASE	8	0	20	11	2	15	56
(d) PNEUMONIA	7	0	26	41	9	19	102
(e) C V A	2	0	1	0	4	2	9
(f) OTHER	2	1	10	0	4	31	48
TOTAL	31	1	81	64	26	85	288

cular accidents were frequently mis-diagnosed in cases of pneumonia with respiratory acidosis and coma, and in cases of congestive failure with cerebral edema, electrolyte imbalance and coma. Only 4 of the 26 clinical diagnoses of cerebral vascular accidents were confirmed at autopsy.

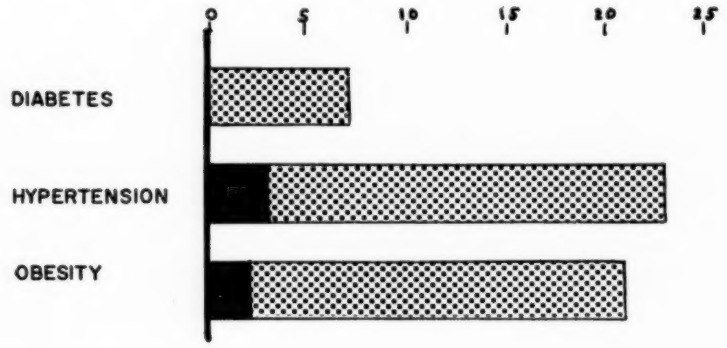
The difficulties of adequate evaluation in the absence of complete autopsy are further enhanced by the fact that differential diagnoses between some of the more common causes of death (pulmonary embolism versus coronary occlusion; hypostatic pneumonia versus congestive failure) are very difficult clinically. Yet the manner of death (accident versus natural) may be correctly ascribed to accidental means in one case and natural in the other.

There were 69 cases of massive pulmonary embolism found at autopsy to be the immediate cause of death. In addition, there were 10 other instances of smaller pulmonary emboli which were considered as contributory but not the immediate cause of death, and 4 cases of fat embolism. Fat stains unfortunately were seldom performed. In the 4 cases of fat

embolism, 2 were male and 2 were female; 1 died six hours after sustaining the trauma, 1 during operative manipulation and 2 in the postoperative period. No instance of bone marrow embolism was noted in the series.

The high proportions of known hypertension, diabetes mellitus and obesity in deaths due to pulmonary embolism are tabulated in Figure 12.

FIGURE 12



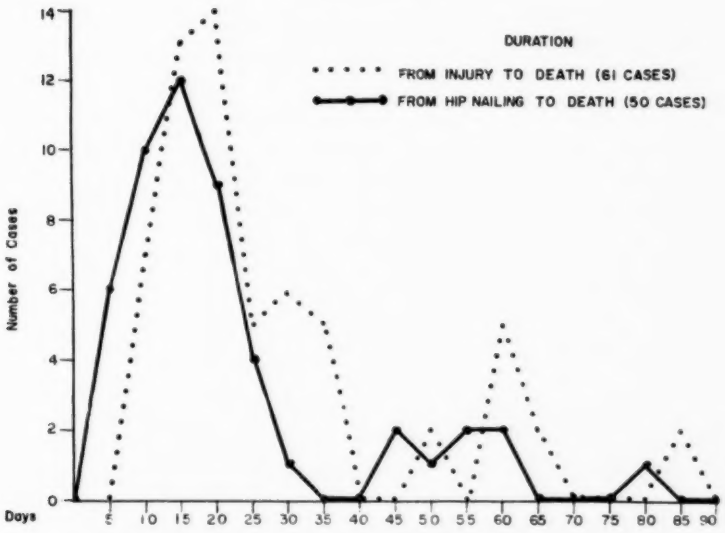
FATAL PULMONARY EMBOLISM

INCIDENCE OF KNOWN DIABETES, HYPERTENSION, AND OBESITY IN 69 CASES (51 ♀, 18 ♂)

⊡·♀ ■·♂

A comparison of the time from injury to death and from surgery to death in the cases of fatal pulmonary embolism is made in Figure 13. More than 63% of the cases of massive pulmonary embolism occurred within 30 days following injury and 88% within 90 days. Of the 57 cases in which surgery was performed, more than 75% of the cases of pulmonary embolism occurred within 30 days. In 9 cases no surgery was performed. Of deaths from pulmonary embolism, 51 were females and 18 males.

FIGURE 13



INCIDENCE OF DEATH DUE TO PULMONARY EMBOLISM

Medicolegal Aspects

The Medical Examiner should by law, as in the Commonwealth of Pennsylvania, be an objective medical authority governmentally established to ascertain if death be due to natural causes and with the authority to perform such autopsies as may be necessary. This authority should be exercised in the interest of law and justice for civil as well as criminal problems. In cases of assumed natural deaths, the cause of death may be only a reasonable or probable one, and the death certificate is actually only prima facie evidence of death. However, when the possibility of litigation or accidental death benefits exists as the result of an injury, the death certificate should accurately differentiate those instances in which death is directly attributable to the injury exclusive of all other conditions from those in which the injury aggravates pre-existing disease or has no significant role.

From the medical and legal standpoint the manner of accidental death is the determination that with reasonable cer-

tainty death would not have occurred so soon had the fracture not been sustained. If death is hastened in any way by the fracture, whether by directly resulting in death or by aggravating pre-existing disease, it is an accidental death. However, this type of death may not fall within the definition of "accidental means" within the contractual provisions of a double indemnity benefit clause of an insurance policy.

To qualify for double indemnity benefits as defined by most insurance policies, death must result directly from the fracture independently of all other causes, usually within 90 days from the time of injury. Further limitation may be made by exclusion of such benefits if infirmity, or any illness or disease contributes to death other than bacterial infection secondary to the injury.

Since the mere designation on a death certificate of an accidental manner in no way necessitates a death by accidental means within the provisions of an accidental death benefit, this type of case has plagued insurance companies with accidental death policies with most inconstant and probably in some instances unfair results.

Prior to January 1, 1932, most insurance companies containing the general accident double indemnity provisions had no age limitation, the insured being covered with double indemnity so long as the policy remained enforced. From January 1, 1932 until January 1, 1954 many insurance companies limited double indemnity coverage to death occurring before the anniversary of the policy on which the insured's age at nearest birthday was 65. Some insurance companies continued to issue accidental death policies with no age limitations. Since January 1, 1954, the age limitation by insurance companies has been extended to the age of 70. Many of the deaths with fractured hips occurring predominantly in the elderly may have policies issued before January 1, 1932, without age limitation, so that the age of an individual at death is in itself no necessary indication that accidental death benefits are entirely excluded.

Case 1. An 89-year-old white female had an intertrochanteric fracture of the left femur resulting from a fall. Because of inclement weather she remained at the hospital the day scheduled for discharge and that night was found dead in bed by the night nurse 11 days after the injury and 9 days

after surgery. The clinical diagnosis was myocardial infarct. At autopsy there was phlebothrombosis of the left leg with massive pulmonary embolism and no other significant findings except for the fracture.

Case 2. An 81-year-old white female 14 days after fracturing her right femur and 11 days after surgical nailing suddenly complained of anterior chest pain while sitting in a chair and died within half an hour. At autopsy the anterior descending branch of the left coronary artery was occluded with a fresh hemorrhagic infarct of the myocardium.

In the first case death could be attributable to the fracture independently of all other conditions rendering the manner not only accidental from the medicolegal standpoint but also due to "accidental means" within the provisions of an accidental death policy. In the second case, even though the fracture may have been considered contributory, and the manner of death as accidental from the medicolegal standpoint, it does not fall within the category of "accidental means" from the standpoint of insurance companies. Since death was due to heart disease, and there is no accepted causative relationship between injury and heart disease, the death is not directly attributable to the fracture. These cases cannot be accurately differentiated in the absence of autopsy.

From the standpoint of "accidental means" defined by insurance companies, therefore, when death is not directly attributable to the fracture, it matters not whether the fracture be considered contributory to death or that the manner of death medically be designated as accidental.

Although accidental death benefits may be restricted by insurance companies to death occurring within a ninety-day period following injury, cases of death by accidental means may occur at a later period.

Case 3. A 32-year-old colored male was struck by an auto while emerging from a manhole, resulting in a fracture of the left femur. After surgical treatment he was discharged 6 weeks after admission and followed as an outpatient. Subsequently, non-union of the femur was noted. Ten months after the injury bone grafts were taken from the tibia and iliac crest, following which he was placed in a double hip spika. He died suddenly after a brief episode of cold perspiration, restlessness and hypotension, 414 days after the initial injury. Death at autopsy was found to be due to pulmonary embolism arising from phlebothrombosis of the left leg. Although death occurred more than a year following injury, this is considered to be death by accidental means. Undoubtedly the 90-day exclusion clause is unfair to

certain individuals who die as the direct result of injuries but who because of sometimes good, sometimes poor, medical care survive for more than 90 days.

The final opinion as to whether or not a fracture of the hip is contributory to death should be made by the Medical Examiner and in a consistent and reasonable manner. In many instances, the pronouncing physician manifests little concept of the role of trauma to death or the possibility of accidental death benefits. One physician may report a fracture of the hip sustained four years before and subsequently healed with complete ambulation as in his opinion contributory to death, whereas another physician may have stated that death was due to a pulmonary embolus ten days following injury, and that the fracture was not contributory.

Case 4. A 66-year-old white female died suddenly 18 days after sustaining a fracture of the left femur. According to the reporting physician, she developed uremia and died of a coronary occlusion. At autopsy there was massive pulmonary embolism arising from phlebothrombosis of the left leg. This woman had an accidental death insurance policy, the benefits of which the beneficiary might have been deprived in the absence of an autopsy, if death had been certified as coronary occlusion or arteriosclerotic heart disease. This may have been true even though the fracture had been listed as a contributory factor, and the manner of death as accidental.

Case 5. A 76-year-old white female died suddenly 13 days after fracturing her right femur and 7 days after surgical nailing. The reporting physician insisted that this was not a Medical Examiner's case, and that the fracture was not contributory. Feeling that the history was very suggestive of a pulmonary embolus, an autopsy was performed demonstrating the cause of death to be phlebothrombosis of the right leg with massive pulmonary embolism. The beneficiary of her accidental death policy would have been deprived of just benefits had the pronouncing physician been allowed to issue a natural death certificate ascribing the cause of death as coronary occlusion.

Unfortunately too many physicians are little aware of the problems involved in death, particularly when the consequence of injury. Issuing a death certificate without reporting such cases to the properly designated legal authority may prove detrimental to the interests of the survivors or direct a suspicion of fraud towards the physician concerned, especially if the body has already been buried. Some death certificates are issued in error because the doctor resides or practices outside the jurisdiction in which the death has occurred, whereas others have resulted from ignorance or negli-

gence. In any case where an injury may be a contributory or causative factor, the physician should be aware that the proper legal authorities are to be notified in the jurisdiction wherein the death occurred.

Case 6. A 74-year-old white female with well-controlled diabetes had an intertrochanteric fracture of the left femur which was nailed the day of injury. The postoperative course was uneventful. She was scheduled for discharge, but "after the strain of moving her on to a bed pan and having a bowel movement, she had a CVA and died suddenly" according to the pronouncing physician who issued a certificate in error, listing death as due to a "CVA," due to arteriosclerosis with the fracture of the hip and diabetes mellitus as contributory. The history suggests pulmonary embolism, but the death certificate so issued prejudiced any claim for accidental death benefits. The body had been buried, and to issue a corrected death certificate contrary to the clinical diagnosis in the absence of autopsy might well create considerable dispute.

Case 7. A 77-year-old white female with a fracture of the left femur, surgically nailed 3 days later, was discharged home. She expired at her residence 59 days after the injury. The pronouncing physician issued a natural death certificate with the cause of death as pneumonia and acute pyelonephritis due to arteriosclerotic cardiovascular disease. The Office of Medical Examiner was notified by the son who stated that she carried an accidental death policy. At autopsy, there was phlebothrombosis of the left leg with pulmonary embolism and infarction. Accidental death benefits were awarded.

In those jurisdictions where there is no legally designated authority to whom such cases are reportable, and the attending physician is responsible for issuance of the death certificates, it is advisable to consult with the family before concluding that death is due to natural causes. When the possibility of insurance benefits or of litigation exists, the family should be given the privilege of an autopsy to negate or confirm the clinical diagnosis.

Case 8. The medicolegal importance of a complete autopsy is emphasized by this case. An 81-year-old white female pedestrian was struck by an auto sustaining a fracture of the left hip. Surgical nailing was performed the following day. She did well for a month during which time laboratory studies were negative. She then developed "chills, fever and shock" with gross hematuria, thrombocytopenia and oliguria. Blood and urine cultures were stated to have grown Proteus sp. The blood urea nitrogen rose to 150 mg. per 100 ml. An electrocardiogram was interpreted as showing auricular fibrillation. She died 41 days after the injury and 40 days after surgery. No autopsy was performed. On the basis of the clinical diagnoses, death was attributed to chronic pyelonephritis due to the fractured hip. The driver of the vehicle was held on a charge of involuntary manslaughter. In view of

the age, the extensive hospitalization, medical and nursing care and the absence of a confirmed cause of death, a competent pathologist could hardly deny in court the possibility that life may have actually been prolonged by the subsequent medical care or deny that there is reasonable doubt that the fracture was actually contributory.

When an autopsy is not performed, and the immediate cause of death is clinically equivocal, it may be preferable to consider the cause of death as undetermined and the manner as unknown, rather than make a casual certification subsequently the subject of an embarrassing difference of opinion in a court of law. Unfortunately, the facts regarding the circumstances of injury, the age of the decedent and the question of litigation are sometimes drastically altered after the body has been buried.

Deaths Directly Attributable to the Fracture

When death is due to the direct effects of trauma, to the complications of treatment, or to the sequelae of immobilization, the fracture is the underlying cause of death. The manner of death is not only appropriately accidental from the medicolegal standpoint but also due to "accidental means" from the insurance standpoint.

The following outline is presented as a consistent and reasonable pathologic physiologic basis for delineating those cases in which death may be directly attributable to the fracture exclusive of all other conditions. In these instances, the fracture of the hip is the underlying cause of death, and the following may be considered as immediate and intermediary causes.

A. Direct effect:
   1. Shock (traumatic or hemorrhagic)
   2. Fat or bone marrow embolism
   3. Adynamic ileus
   4. "Crush" syndrome: acute tubular necrosis of kidneys.

B. Complications of treatment:
   1. Operative and anesthetic deaths
   2. Fat and bone marrow emboli during manipulation
   3. Operative and postoperative shock
   4. Pneumonia following aspiration during anesthesia

5. Postoperative adynamic ileus
6. Postoperative cellulitis, osteomyelitis and their sequelae
7. Postoperative tubular necrosis of kidneys
8. Enterocolitis (micrococcal) following antibiotic therapy
9. Therapeutic misadventure

C. Sequelae of immobilization:
1. Hypostatic pneumonia
2. Phlebothrombosis: pulmonary embolism
3. Decubitus ulcers: cellulitis, osteomyelitis, bacteremia, etc.—

Discussion

The subject of thrombo-embolism is a complicated one subject to dispute and confusion recently extensively reviewed by DeBakey (7). A significant incidence of pulmonary embolism resulting in death in cases of fractures of the hip has been reported by others (8). Allen's report (9) indicates a definite relationship between a fracture of the hip and pulmonary embolism, although his results were not confirmed (10). Immobilization is probably a significant factor in studies based on institutionalized individuals which reported a high incidence of pulmonary embolism (11).

It is probable that phlebothrombosis more frequently follows immobilization and stasis rather than being a direct effect of trauma, although other factors may play a considerable part. In the absence of evidence to the contrary, pulmonary emboli resulting from thrombi of veins of the legs in individuals with fractured hips are considered a cause and effect relationship and a death by "accidental means."

Medical opinion has long held that recumbency in elderly individuals frequently results in prevalence to hypostatic pneumonia and ultimate demise. Although this opinion may be questioned, in spite of the work of Laplace and Nicholson (12), there has been no significant contribution in confirming, negating or in elucidating the pathologic physiologic mechanisms involved. The data, however, indicate that immobilization induced by the fractured hip is a significant feature in many of these deaths, and the sequelae of hypostatic pneu-

monia and thrombo-embolism probably bear a direct relationship to the injury sustained.

There are occasional cases in which the time relationship of death to the injury is so closely approximated that although death may be due to underlying disease, the fracture is probably contributory.

Case 9 was an 86-year-old white male with hypertensive and arteriosclerotic cardiovascular disease for 15 years, congestive failure for more than a year with stasis dermatitis and marked hepatomegaly. Several hours following a fall fracturing his left femur and admission to the hospital, he developed acute pulmonary edema with severe bilateral effusions and expired less than 24 hours following the injury.

It seems reasonably certain that had the injury not been sustained, death would not have occurred so soon. In this type of case, although the manner of death is ascribed as accidental, the death certificate should indicate that death is due to natural disease, either aggravated by the fractured femur or with the fracture listed as contributory.

Deaths due to coronary artery disease, cerebral vascular accidents, pulmonary tuberculosis, cirrhosis of the liver, malignant tumors and other conditions are probably natural deaths, with the fracture of the hip a concomitant feature not significantly contributory to the pathologic physiology producing demise. A definite relationship between a fracture and subsequent occurrence weeks or months later while at bed rest, or a coronary occlusion with infarction, for instance, is difficult to sustain, although not entirely refutable. When these types of cases, however, are compared to the total deaths for each age group there is no significant effect on the mortality rate. The subsequent medical and nursing care probably equals or exceeds the effects of trauma.

The following summarized cases are illustrations of those in which the fracture of the hip is probably not significantly contributory to death. Although an accidental death certificate had been issued by others listing the fracture as contributory or aggravating the pre-existing disease, entirely natural death certificates are issued by the author. This opinion may be subject to dispute.

Case 10 was an 82-year-old white male with an intertrochanteric fracture of the right femur due to a fall to the floor while in a nursing home. He

was admitted to the hospital the same date and 4 days later, surgical nailing was performed; 40 days after the injury his blood pressure suddenly dropped, respirations increased, he became comatose and died 3 days later. At autopsy, severe generalized arteriosclerosis with a ruptured abdominal aneurysm and massive retroperitoneal hemorrhage was found.

Case 11 was a 78-year-old white female who fell down a flight of stairs sustaining a fracture of the right femur, was hospitalized and placed in traction. She was diabetic and obese. 47 days later, she had a sudden drop in blood pressure, shortness of breath and chest pain and in spite of appropriate therapy, expired the following day, 48 hours after the injury. Death was due to sclerotic occlusion of the right coronary artery with a 2–3 day old myocardial infarct.

Case 12 was a 77-year-old white male with a past history of duodenal ulcer for many years, who fell at home fracturing his left femur. No surgery was performed because of heart disease. He did well and was out of bed in a chair. He began to have bright red stools, complained of severe abdominal pain and expired 17 days later. At autopsy there were two duodenal ulcers, one with perforation and acute peritonitis and the other eroding the pancreaticoduodenal artery with massive gastrointestinal hemorrhage. In addition, there was a bronchogenic carcinoma with metastases to the superior mediastinal and paratracheal lymph nodes.

Case 13 was a 65-year-old white male under treatment for pulmonary tuberculosis who fell on the bathroom floor of his residence, fracturing his right hip. He expired in the hospital 29 days later and 21 days after surgical nailing. Although the fracture was not pathological, at autopsy there was an anaplastic carcinoma of the right lung with metastases to the liver, adrenals, kidneys, bone and brain in addition to portal cirrhosis and pulmonary tuberculosis.

Case 14 was an 81-year-old white female under a physician's care for 5 years for high blood pressure and had had a splenectomy 3 months before with a pathologic diagnosis of granulocytic leukemia. She expired 29 days after falling in the kitchen when she apparently had a stroke. At autopsy, there was a large intra-cerebral hemorrhage.

Case 15 was an 87-year-old white female with a fractured left hip surgically treated and discharged to a nursing home where she expired 59 days after the injury, and 52 days after the operative procedure. Death was due to thrombotic occlusion of the right coronary artery with a less than 2–3 day old myocardial infarct.

Case 16 was a 71-year-old white female with a fracture of the left femur and a history of congestive failure. Following surgical nailing 3 days later, she was out of bed in a chair for long periods with a satisfactory course until 2½ weeks later she developed a left hemiplegia and lapsed into coma. At autopsy, there was encephalomalacia of the right parietal and both occipital lobes and sclerotic occlusion of the right coronary artery with anterior and posteroseptal infarctions of the myocardium.

Deaths attributable to spontaneous fracture following pathological conditions of bone are natural deaths. No problem

arises when the pathology is neoplastic. However, with osteoporosis and Paget's disease of bone common in the elderly, it may be difficult to determine if a spontaneous fracture occurred with a subsequent fall, or whether minor trauma resulted in a fracture of diseased bone. In the latter course careful evaluation is necessary to determine if the injury were of sufficient degree to have produced a fracture in a normal hip. Doubtful cases are fairly considered as accidental.

In rare cases although the immediate cause of death may be directly attributable to the fracture, it is not possible to determine whether death is actually the sequela of the fracture or of pre-existing bodily infirmity or disease. Again doubtful cases are considered as accidental.

Case 17. A 68-year-old, obese white female with hypertension for 15 years and intractable congestive failure for 3 years died with hypostatic pneumonia 2 months after a hip fracture for which she was continuously hospitalized. In spite of intensive therapy she was still in failure at the time of death. The pneumonia was considered secondary to the fracture, although one might reasonably conclude that the pneumonia was the consequence of chronic congestive failure, and that the fracture actually played no significant role.

Once the fracture has completely healed and ambulation has occurred, subsequent deaths may be considered natural, unless clearly proved to the contrary.

A final point may be made; namely, that the death certificate should clearly define the role of the fracture. Some death certificates manifest little concept of physiologic relationships. An illustrative example is one in which the death was certified as being due to "Respiratory failure" due to "Fracture of the right femur" due to "Retained secretions." Although still not satisfactory, at least a better arrangement would have been to state that death was due to "Respiratory Failure" due to "Retained Secretions" due to "Fracture of the Right Femur."

Summary

Five hundred eighty-two cases of deaths with fractured hips reported during the first two years of the Medical Examiner's System in Philadelphia are reviewed and evalu-

ated. The importance of differentiating those cases in which death is directly attributable to the injury from those in which the fracture is either only a contributory factor aggravating pre-existing disease, or plays no significant role, is stressed.

When death is due to the direct effects of trauma, to the complications of treatment, or to the sequelae of immobilization, the fracture is the underlying cause of death, and the manner of death must be certified as accidental. A basic outline for delineating this type of case is presented.

When initial shock is overcome, and proper treatment instituted, deaths occurring weeks or months later due to unrelated and independent causes are probably natural deaths.

The difficulties of accurate evaluation in the absence of autopsy, and the medicolegal aspects are emphasized.

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AMERICAN ACADEMY OF FORENSIC SCIENCES
ELEVENTH ANNUAL MEETING

February 26, 27, 28, 1959

DRAKE HOTEL—CHICAGO, ILLINOIS

1. SYMPOSIUM ON THE INVESTIGATION OF SUICIDES

Criminalistics	Psychiatry
Pathology	Legal Aspects
Toxicology	Questioned Documents

2. WHAT'S NEW IN THE FORENSIC SCIENCES

Nalline: Some Legal Implications in Its Use*

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Narcotic addiction is unquestionably one of the major problems in the United States. No one knows statistically the extent of this problem; in California, a few years ago, it was estimated according to a Citizens' Report (1) on addiction that there were some 20,000 persons using narcotics illegally. In this same report it was of interest to note that in 1949 addiction was so low that Congress wanted to close the hospitals at Fort Worth (Texas) and Lexington (Kentucky).

To reduce addiction there are several approaches—public education, stiffer penalties on those who peddle the drug, controlling the illegal entry of narcotics in this country, and finding and treating those who are addicted. This paper is concerned with the latter.

In a recent article by Terry and Braumoeller (2), Nalline is discussed as a drug which, in addition to its other uses, can be used as an aid in detecting the illicit use of narcotics. For our purposes, it will suffice to say that when Nalline is administered to a person who has been taking heavy doses of opiates, withdrawal symptoms are produced. The severity of the symptoms varies with the dosage of Nalline given and the degree of addiction. There is increasing use of the Nalline test throughout California, and I am certain throughout the country where opiate addiction is a problem. As any new scientific discovery, it might attract our attention to the extent that we lose sight of other measures. It should be

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remembered that Nalline is only an aid in the detection of drug addiction. There are still other methods which have stood the test of time, e. g., the presence of needle marks on the arm, illegal possession of the narcotics, physical appearance while under the influence of the drug, development of withdrawal symptoms when isolated, etc. (3) Furthermore, I could think of nothing that would make a prosecutor happier than a signed confession of addiction.

Constitutional Issues

Consent. The law attempts to protect certain individual rights of its citizens. Hence, to use Nalline just as in the use of any alcoholic test, the consent of the individual is required. To comply with this in Alameda County, California, the patient is given a standard form of authorization to sign. According to Black's Law Dictionary (4), consent is an act of reason, accompanied with deliberation, the mind weighing as in a balance, the good or evil on each side. It further states "there is a difference between consenting and submitting. Every consent involves a submission; but, a mere submission does not necessarily involve consent."

Within the confines of a police station there is always promulgated an issue as to whether consent was real or was forced by the circumstances of the environment. It is frequently contended that there was not consent but submission; each case, of course, has to stand on its own. Furthermore, if the subject is under the influence of a narcotic at the time consent is given, is his state of mind such that we can say he has consented? This can only be of academic significance, since if he contended that, he would in effect be admitting his guilt.

Self-incrimination. The Fifth Amendment of the Federal Constitution states in part, "no person . . . shall be compelled in any criminal case to be a witness against himself." In the use of Nalline where the suspect is used, it could be contended that if submission to the test is required, this would involve obtaining from the subject, by means of involuntary bodily responses, testimony which could be used against him, and thus, in effect, cause the subject to incriminate himself. However, in Holt v. United States (5), Holmes, J., said that

the prohibition against compelling a man to be a witness against himself is "a prohibition of the use of physical or moral compulsion to extort communications from him, not an exclusion of his body as evidence when it may be material." The majority of courts today still follow this rule.

Cruel and Inhuman Punishment. Mauer and Vogel (6) state that "large doses of this drug (Nalline) will precipitate signs of withdrawal so sudden and so severe that death may result." The last portion of the Eighth Amendment of the Federal Constitution states "nor cruel and unusual punishments inflicted." When an incarcerated addict develops the agonizing pains of withdrawal symptoms, because he has been separated from the drug, we have one situation; but, for the authorities to give him a drug to induce these pains—we certainly are faced with a constitutional problem. This should caution us that physicians giving Nalline should be well-versed as to proper dosage, recognizing withdrawal symptoms, and being prepared to treat them. I had the pleasure of watching Dr. Terry in Oakland, California give the test and was greatly impressed by his gentle handling of addicts and meticulous use of the drug.

Evidentiary Issues

Judicial Notice. In a rather old California case (7), the California Supreme Court laid down the rule that the three requirements of judicial notice of matters of fact are "that the matter be one of common and general knowledge, that it be well-established and authoritatively settled, be practically indispensable, and that this common, general and certain knowledge exist in the particular jurisdiction." The use of Nalline to detect addiction is new, even to the medical profession. Hence, it must be introduced in evidence by the ordinary processes of proof. As to whether courts, in time, will take judicial notice of the test, I am not prepared to say. I would like to quote a statement of The American Law Institute (8) on judicial notice of scientific facts.

> ". . . it is to be remembered that the sources for demonstrations of a scientific truth, not yet known to intelligent and reasonably well-educated laymen, may not be readily accessible, or if accessible, may be in a form

> not intelligible to laymen. And in such cases, it is entirely fair to require the party relying upon that truth to make it known to the trier by the ordinary processes of proof. It is not to be forgotten that a lawsuit is not a scientific investigation for the discovery of truth, but a proceeding to determine the basis for, and to arrive at a settlement of, a dispute between litigants."

Refusal to Consent. We have already discussed some of the ramifications of consent as a constitutional issue. Suppose the suspect refuses to consent to the Nalline test? Can his refusal be admitted in evidence by the prosecution in the trial?

If we are to hold that taking of the Nalline test is akin to a form of self-incrimination, then under the majority of jurisdictions, by statute or judicial decisions, no inference may be drawn by reason of his claim of the privilege against self-incrimination. It follows that comment on his refusal to consent is forbidden. Ohio and California and some three or four other jurisdictions, however, have constitutional amendments which specifically authorize comment.

On the other hand, if Nalline testing is not self-incrimination, then there is no privilege; and, I see no reason why comment about his refusal to consent cannot be made in all jurisdictions.

Circumstantial Evidence. At this point we might re-emphasize the importance of other evidence in drug addiction. I would like to call your attention, again, to the article by Dr. Terry. The author stated that since the use of Nalline there has been only an occasional trial, the great majority of defendants now enter a plea of guilty. However, suppose the only evidence we had was the Nalline test? Would it be sufficient circumstantial evidence to warrant a conviction? In California, to justify conviction on circumstantial evidence alone, circumstances must not only be consistent with the theory of defendant's guilt, but, inconsistent with any other rational conclusion (9). A case in Ohio holds that in order to warrant a conviction on circumstantial evidence alone, the facts and circumstances must be such as to exclude every other reasonable hypothesis, but the single one of the defendant's guilt (10).

The crime we are attempting to prove is under the influence of opiate. It is known that with Nalline, withdrawal-like symptoms may be produced in the person, not under the influence of any opiate, if given in a larger dose than ordinarily used. What's to keep the defendant from claiming that he might have been given, perhaps inadvertently, the larger dose? The decisive point, of course, is the pupillary response. In the drug-free person the pupils constrict, while in the addict, the pupils will dilate. Although this may be a strong line of circumstantial proof, it is still nevertheless, a rather thin one.

The Expert Witness. Only a physician should be permitted to give the Nalline test. No problem, therefore, arises as to his qualifications to testify as an expert witness. In Oakland, Califorina, where the test is administered by Dr. Terry, he is assisted by police officers; the same is probably true in other areas. To have a physician, who is usually a very busy person, come in to testify on each case might create quite a burden on him. The question arises, as to whether his assistant, who may not be a physician, can testify as an expert? In People vs. Johnson (11), a California case, a police officer, who had assisted in 262 cases, testified that a Nalline test would not show if the person tested was a light user of heroin, if such test was given three or more days after the last fix. This testimony was objected to on the grounds (a) that the police officer was not an expert, and (b) that he had obtained such information from a medical officer, and as such, was hearsay. The Appellate Court held such testimony was not inadmissible. An expert's opinion must be based upon his own personal knowledge (which was the case here) and, whether a witness qualifies as an expert is a matter largely within the discretion of the trial court and questions about his degree of knowledge go to the weight, rather than to the admissibility, of his testimony.

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PLAN TO ATTEND
ELEVENTH ANNUAL MEETING
AMERICAN ACADEMY OF FORENSIC SCIENCES

February 26, 27, 28, 1959
DRAKE HOTEL CHICAGO, ILLINOIS

Typewriting Impressions: Testing and Differentiation by Chromatographic Adsorption*

Linton Godown, Chicago, Illinois

Introduction

The past few years have seen an almost complete revolution in the methods whereby some of the elements making up a document may be tested and differentiated. The newer methods of chemical analysis such as paper partition, ion exchange, adsorption and reverse phase chromatography, and paper electrophoresis have provided new horizons, especially in the testing of inks where their sensitivity, simplicity and ease of demonstration have attracted the attention of numerous workers. In those aspects of document examination where chemistry might extend a much-needed helping hand with objective testing methods there are two that have received little or no attention. One is the testing of pencil markings and the other the testing of typewriting impressions, the subject of this investigation.

Since the turn of the century the steadily increasing use of the typewriter to prepare important documents far surpasses the most optimistic dreams of early writing machine promoters. Almost from the beginnings of commercial and legal use of the typewriter there have been questions involving the authenticity and dating of typewritten documents. Occasionally it becomes important to determine whether or not two writings may have been prepared on a designated typewriter on

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or about a particular time. A portion of the solution to such problems requires careful consideration of the physical evidence of the condition of the type of the machine as indicated by the written product. In some instances the examiner may be materially handicapped by inability to perform satisfactory objective comparisons of those qualities of the impressions not involving design or mechanical defects.

Nature of Typewriting Impressions

The early typewriters used either of two methods for making their writing visible. Some provided means whereby the raised type was supplied ink from a pad prior to its impression on the writing background. Others employed the now almost universal principle of interposing some inked material between typeface and background to transfer the design to the paper. In the early typewriters, and most of the machines in current use, this is accomplished by use of a cloth ribbon impregnated with an oily ink which moves in and out of writing position with each type blow. The mechanical arrangement also provides for progressive lateral movement of the ribbon so that successive blows do not fall repeatedly on the same spot. This feature serves two useful purposes, that of distribution of mechanical wear over the ribbon surface, promoting longer fabric life, and provides a rest or recovery interval in which used ink is replaced by fresh ink by capillary flow within the fabric.

The ribbon is used until the ink is materially depleted. The pad inking feature has not survived on office typewriting machines although it is found on some toy machines and is used by other office devices. There are other seldom-encountered methods of typewriting in which the image-creating materials are inherent in the writing background, such as "NCR Carbonless Paper" and a wax surfaced colored paper occasionally used for restaurant menus. These will not be considered.

In recent years there has been a trend toward substitution of a narrow ribbon of carbon paper for the fabric ribbon. This material is used for a single impression and then usually discarded. Particular qualities inviting adoption are the sharper, clearer impression, due to thinner structure, causing

less diffusion of the force of type impact, and the uniformity of impression that comes from the single use of the inked surface. Carbon ribbons are not common even with the late model typewriters. They are more frequently in use where typewritten copy is prepared for photographic methods of reproduction. Cellulose acetate carbon support finds occasional use.

Of the fabrics available for typewriting ribbons, cotton is the most widely used. Its best application involves use of long fibers which permit weaving a thin, hard ribbon of good wearing qualities which favors optimum ink recovery as well. Thick fabric tends to reduce impression sharpness while short fibers hamper capillary ink flow and prompt recovery. Silk has many desirable qualities and is held in highest regard by some critical consumers. The synthetic fibers find some use and both nylon and rayon are encountered. Various fibers contribute special manufacturing problems, which have been met in part by special ink formulas. Some manufacturers supply various fabric types; further diversified by degree of inking and other qualities.

So far attention has been confined to what might be termed the primary typewriting impression or original. The process also permits simultaneous preparation of a limited number of additional impressions or copies. Ordinarily this is accomplished through the use of alternate sheets of writing paper and carbon paper. There have been occasional commercial devices intended to multiply impressions by use of fabric ribbons. The usual gadget is an appliance permitting the insertion of several short lengths of fabric ribbon between the sheets of writing paper to remain stationary in the writing line while the paper advances around the platen.

The nature of materials used to make auxiliary impressions is similar to those for primary impressions. The testing of both may be considered together. A special consideration where copies have been made may arise when the force of impression results in type with sharp faces rupturing the paper surface and possibly the first carbon sheet as well. This condition can result in primary impression material being carried through to the carbon copy impression, the carbon material transferring to the back of the original and possibly

some contamination of the original impression with carbon material.* Instances have also been observed in which fragments of material used to print the trade mark and brand on the uncoated side of the carbon sheet have transferred to the back of the original in a manner assisting in forming an opinion regarding writing conditions.

Fabric and Carbon Inks

The most popular impression material is black. Permanent types are designated "BLACK RECORD," which indicates that the main pigment is some form of carbon black. Such blacks have deep color and are inert chemically. A few black ribbons are sold using a black dye which can be bleached with a two-solution "eradicator," but these are seldom encountered.

Sources on formula data regarding black inks for ribbons and carbons indicate that the two products have much in common. Both are frequently made by the same manufacturer. As indicated, the main ingredient is carbon black. When spread thinly, as in a typewriting impression, it has a brownish appearance. It is a long established custom to counteract this warm appearance by addition of oil-soluble dyes called "toners." These are usually blue, violet or black dyes dissolved in oleic acid (red oil), although occasionally colored pigment may be used. The result is a deepened jet black color of greater intensity and more pleasing appearance.

The two classes of impression material differ most with respect to the type vehicle or carrier employed. Fabric inks are pasty, semi-liquids with an oil, or oily jelly base. They are applied to ribbon fabric without heating. Carbon coatings have a carnauba wax base which is fluid only when heated. They are applied to a paper support in a molten state. Published ribbon and carbon ingredients are shown in the accompanying table (table I) which indicates the overlapping nature of the materials as well as the differences in vehicles. Modern commercial compositions may differ in detail from the published formula but are similar in principle.

* For a general account of ribbon and carbon manufacture, the discussion by Waters (3) is highly recommended. No formula details are supplied, however.

TABLE I. BLACK INK COMPOSITION *

FABRIC INKS (applied cold)	VEHICLES:	Mineral oils and jellies. Occasionally animal or vegetable oils (non-drying); Neat's Foot, sperm, lard, rapeseed, castor or sulfonated coconut.
		Oleic Acid (red oil); toner solvent and wetting agent.
		Natural or synthetic waxes as "lustering agents"; as montan, paraffin, etc.
		Occasionally tricresyl phosphate, diglycol laurate, glycol ethers and water soluble additives may be used.
	PIGMENTS:	Various forms of carbon black. Occasionally other blacks as Ceylon Graphite, black-lead.
	TONERS:	Dye or dye mixtures. Rarely pigment. Blues as victoria, milori, alkali, violet, prussian or iron blue. Violets as methyl or crystal violet. Nigrosine or induline bases.
CARBON COATING (applied hot)	VEHICLES:	Waxes, usually carnauba modified by other waxes as paraffin, ozokerite, japan, beeswax, montan or candelilla.
		Oleic Acid (red oil); toner solvent and wetting agent.
		Oils, usually petroleum oils and jellies; less commonly vegetable or animal as linseed, castor, cottonseed, sesame or lard oils.
		Rarely; tallow, gutta percha, soap.

* Compiled from various sources (9) to (18). Except for disclosure of governing principles, skepticism regarding details of published formulas and patents may be justified.

It is a common occurrence for the fabric of the ribbon to outlast its original ink supply. This has fostered many suggestions for re-inking or otherwise extending the useful ribbon life. Except for very large consumers it is doubtful that they offer any real economy. Methods run from reapplication of suitable ink under proper conditions, through application of a more fluid ink, to adding clear oil or placing the depleted ribbon in a solvent atmosphere. The last two ideas are intended to promote redistribution of dye within the fabric from unused edges to the wear area. The messy, temporary and impractical nature is obvious. However, the use of this method might have great identification value in a particular case.

Impression Comparison Methods

Occasionally the document examiner finds it necessary to make a critical comparison of two or more typewriting impressions. The question commonly is whether the impressions exhibit sufficiently different qualities to force a conclusion that they could not have had a common source. Not infrequently questions arise as to whether a typewritten addition or interlineation was contemporary with the main preparation of the document or whether a specific document is consistent with other typewritten documents known to have been prepared at that date.

Two examination methods using physical features are available. Both involve visual comparisons and can sometimes be implemented by the comparison microscope. The color, line width and intensity of the writings may be compared making proper allowance for variables that might affect accurate judgment, such as those arising from mechanical sources, the human operator element or conditions surrounding the writing. In some instances visual differences of this nature provide substantial and persuasive evidence. More often sound judgment of subtle differences in color in the range of dark blues, violets, browns and blacks should be recognized as difficult and possibly misleading. At best, conclusions are difficult to demonstrate to others. What may be interpreted as an obvious color difference by one observer cannot be distinguished by another, or by the original observer under modified lighting conditions.

Under favorable conditions it may be possible to compare impressions resulting from the weave of the fabric and compare the number of threads making up the warp or woof. Except in the unusual case, "thread count" seldom supplies reliable evidence.

Chemical Testing of Impressions

Apparently the earliest published information on the use of chemical methods for testing fabric ribbon impressions was by Cassidy (1) who in 1942 directed attention to chemical reactions which he ascribed to differences in toners. He based his conclusions on a novel and original testing technique applied to some two hundred black fabric ribbon samples collected from commercial sources. Details of his testing method were privately circulated to those indicating a legitimate need for the information. His paper also discussed important aspects of the overall problem involved in chemical testing of disputed documents as well as basic principles of the logic of identification sometimes insufficiently recognized.

The following seems appropriate for quotation here:

> "The words 'differentiate' and 'distinguish' . . . must not be confused with the word 'identify.' The writings of different classes of typewriter ribbons of the 'Black Record' variety can be 'distinguished' as to class but cannot be 'identified' in any conclusive manner as the work of any particular brand or individual ribbon."

Following the Cassidy (1) report several simple techniques were developed and widely used by workers to dissolve and flush toner dyes from typewriting impressions to some position on the writing background where they were unobscured by the carbon and could be observed and compared. A number of liquid organic solvents were found useful, including commercial solvent alcohols. The toners thus revealed were classifiable according to the observed color. The number of classes that could be practically distinguished was limited, if restraint was exercised to avoid being misled by apparent differences that might stem from quantitative factors rather than qualitative.

More recently Brown and Kirk (2), apparently unfamiliar with these methods, published the result of investigations into

testing ribbon impressions. After exploring possible applications of paper partition chromatography and electrophoresis, the methods were reported as lacking sufficient sensitivity. A technique was developed using comparison of colors obtained in simple solutions through the use of four selected solvents. This technique was considered as successful in "identification" and complete classification of the ten ribbon samples investigated.

Consideration of the nature of the compositions involved certainly indicates that the possibility for extending differentiation lies with the variables of vehicle and toner. The high tinctorial power of dyes and the newer techniques that can be applied to their separation even in minute quantities suggests development of testing techniques not restricted to consideration of their overall color.

Proposed Chromatographic Adsorption Technique

Experiences with the application with modifications of adsorption and paper-partition chromatography, and paper electrophoresis to related ink testing problems indicated their possible adaptability to testing typewriting impressions (4), (5), (6). Preliminary exploration of those using paper confirmed the report of Brown and Kirk (2). Neither was sufficiently sensitive for practical use in testing the dye toner available from minimum samples of typewriting.* Powder adsorption chromatography indicated sufficient sensitivity.

Experiments were made using several common adsorbents (alumina, starch, asbestos powder, talc) in combination with assorted organic solvents. Final selection was the use of thin films of talc on glass plates and a 1:8 alcohol-acetone solvent. A number of other combinations were found usable but less effective. An important consideration involved the fluorescence of the adsorbent in ultra-violet light. Strong background fluorescence arising from the adsorbent limits detection of fluorescing fractions in the chromatogram. The thin

* In civil document examination the limitations placed on adequate samples for analysis are sometimes severe. Sampling, however unobtrusive, invites complaint of document mutilation, defacement and damage from those "against the facts."

film technique had been previously successfully employed with writing inks (4) and is an adaptation of suggestions of Williams (7), (8) regarding the use of disc type chromatograms for rapid selection of suitable adsorbents and solvents.

The method requires formation of thin films of powdered adsorbents of glass supports. Microscope slides or 2″ x 2″ cover glasses are convenient. Films are formed readily by spraying or otherwise coating the glass with a slurry of adsorbent in liquid. An even coating sufficient to partially obscure newsprint is permitted to dry at room temperatures with the glass slides on a level support. Proportions of adsorbent to fluid are not critical. With talc one part to five of distilled water was found satisfactory. No binder was found necessary.

Application to practical document testing requires the removal of small specimens or samples of the typewriting impression from the document. Attempts to remove soluble portions of typewriting in solution were unsuccessful. The class solvent required to release the toner diffuses rapidly into the paper and cannot be recovered. Brown and Kirk (2) appropriately suggest removal of a few fibers bearing impression material by means of jewelers forceps. Another effective sampling method is to use a modification of a leather drive punch which permits cutting a $\frac{1}{32}$″ disc bearing typewriting from an appropriate location. With careful manipulation the cut need extend only partly through the sheet so that, by using forceps with tip honed to a knife edge and a skiving cut, only the upper layer of paper need be removed.

After removal the sample is placed on a small clean glass plate in contact with the lower end of a perpendicular capillary glass tube. Solvent is applied to the sample dissolving the toner which flushes from the sample to the column of solvent rising in the capillary tube. Several small applications of solvent are used to assure removal of all toner possible. Following the final application, contact between the sample and capillary tube is quickly severed to prevent reconcentration of toner in sample as the result of evaporation. The glass plate with the exhausted sample is replaced by an adsorbent coated plate. On contact between the lower end of the capil-

lary tube and the adsorbent layer the solution flows gradually from the perpendicular tube forming an expanding circle in the film. The pigments and dyes are deposited, the dyes being adsorbed on the powder in accordance with their properties in the particular adsorbent-solvent combination. A disc-like chromatogram is formed from a radiant point where the tube touched the film. No development of the chromatogram by use of additional solvent was employed.

The method outlined is sensitive to minute amounts of the toner dyes. Patterns are formed as shown by colors, band width, and location with respect to center and periphery of the circle (front). The patterns are apparently related to the various qualities of the toner although it is not intended to suggest that fractions of the vehicle may not also be present.

Various methods of critical comparison of the chromatograms are available. Visual inspection may be supplemented by ultra-violet fluorescence comparisons, viewing by infrared electronic converters, or comparative photography by controlled lighting. In some instances it may be desirable to also compare the sample residues.

The technique is readily acquired. The necessary manipulations are easily accomplished. Some magnification is helpful. The necessary apparatus is simple and inexpensive. No unusual or expensive reagents are required. The entire technique can be carried out at the location of impounded documents or samples, or properly identified and protected, and may be removed for laboratory testing. It appears to have the requisites of a practical method.

The thin films of adsorbent on glass are fragile and readily damaged by accidental contact. Properly supported by their edges in common microscope slide containers they have proved surprisingly rugged and are readily transported, using only ordinary care.

As with other testing techniques applied to forensic problems, there is considerable question whether it is advisable to testify regarding results obtained unless prepared to meet vigorous informed cross-examination on technical aspects of the technique used. As with any method, interpretation of results requires experience with its application to problems of the same nature as that under consideration.

Experimental Application

Following the development of the working technique as outlined, the method was applied to testing typical specimens of known impression material. Carbon and fabric ribbon samples were assembled from leading sources normally serving business and professional consumers. The product of most leading manufacturers was obtained with allowance for the commercial practice of marketing the same product under various brand names and by different organizations. Machine designations were disregarded as only significant of hardware and dimensional differences. The effort to obtain a cross-section of representative black impression materials resulted in a collection of twenty-nine fabric ribbons and ten carbon ribbons (including one coated on cellulose acetate). With one manufacturer a sample was obtained from each stock item thought to represent price or material factors that might affect ink formula.

Impressions were made from all the collected samples on Whatman filter paper and from these impressions chromatograms were made from each material. The results obtained do not permit simple classification, tabular presentation or intelligible verbal description. Sufficient variation was found in the reaction of the various impressions to demonstrate a greatly increased opportunity for differentiation of typewriting. For example, six different fabric ribbons of a single manufacturer were found to exhibit reactions distinct from each other. The chromatograms were formed on microscope slides in such a manner that they could be stored without damage and used as reference material. By appropriate arrangement chromatograms of the type made can be effectively compared using the comparison microscope and moderate magnification.

Visually similar chromatograms were frequently readily distinguished when viewed under ultraviolet. Prominent fluorescence was observed using the **3650 A band** and to some extent in the **2537 A band.** Detection and interpretation of fluorescence was materially enhanced by using a series of visual filters. Their effect was two-fold; the general spectral region of fluorescence was indicated and in many instances they effectively suppressed a pronounced fluorescence in one spectral region and permitted observation of the fluorescence

of adsorbed fractions emitting fainter, previously masked fluorescence.

It was apparent while applying the method that it could be adapted in substantially similar form to the testing of other types of writing impressions. No material change is required to extend the testing technique to the writing done with ball pens or the impressions of rubber stamps. With some modification it can be applied successfully to some classes of pencil writings. Preliminary experiments have been made with such applications but are not within the scope of this report.

Throughout the experimental period, despite the considerable expansion of possible differentiation between similar impressions, no results were obtained which could be properly described using the word "identify" or "identification" in the forensic sense. Cassidy's (1) caution should be re-emphasized —that obtaining substantially similar results by this or other testing technique is proof only of membership in a common class, not "identity."

Summary

Thin film adsorption chromatography is suited to qualitative comparison of minute traces of components of some writing elements.

The use of a talc-alcohol-acetone or similar system with an appropriate handling technique, such as described, permits differentiation between black typewriting impressions made with different but similar materials within the fabric ribbon or carbon impression classes.

There is no means known at present whereby typewriting impressions can be chemically tested and determined as having an "identical" source although the possibility of differentiating or distinguishing between impressions from similar sources has substantially improved.

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A Study of Class Characteristics of Autoloading Weapons

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In firearms identification work we frequently refer to class characteristics of weapons, and are concerned with the transmission of these characteristics to fired bullets and fired cartridge cases.

If we consider this matter in the broadest sense, we can say that certain types of autoloading pistols produce similar class characteristics. The basis for such a statement is the fact that all are of the same caliber, all are of the same functional design, all are equipped with extractors and ejectors, all have ejection ports on the same side, and the rifling is similar from the standpoint of the number of lands and grooves and direction of twist. This obviously takes in a large number of makes and models. We can however, subdivide this large group into many sub-groups on the basis of certain factors such as location of extractor, relative location of extractor and ejector, type of breech face machining, and on the basis of a more critical analysis of the rifling. Then we substantially impart a meaning to our statement that a "similarity of class characteristics" is present.

This study can be further narrowed down to the individual weapon. Our work is primarily at this level, and we have concerned ourselves with detailed examination of fired cartridge cases and bullets from different weapons of the same makes and models, for the purpose of determining extent of similarity in reproduction of the various characteristics.

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All this might suggest that our efforts are concerned with the collection of data which might be useful in the determination of make and model of the weapon through the study of fired cartridge cases and bullets. We are aware of the possibility of such a conclusion, because the study of class characteristics was usually linked with such a purpose.

In the early development of firearms identification, the theory that it should be possible to determine the make and model of the weapon from the study of fired bullets and fired cartridge cases was advanced. Some writers did not wait for research to determine to what extent this might be true. Apparently, in their enthusiasm for the new science of "Forensic Ballistics," they went off the deep end so to speak, and made strong dogmatic statements, which advanced this theory to the position of proven facts. Unreasonable claims were not confined to popular reading material. One such example reads as follows: "After examining a bullet they are able to state the make, caliber, type, approximate date of manufacture and the approximate serial number of the gun from which it came." (1)

This situation naturally prompted research, and eventually supporting facts and limitations were uncovered. One of the most outstanding pieces of research on this matter can be credited to Mezger, Heess, and Hasslacher (2). These investigators succeeded in developing a classification system whereby autoloading pistols can be grouped into different types on the basis of method of ejection, form of ejector, certain basic chamber forms and relative position of extractor, type of breech face finish and cuts in its shape to accommodate ejector, etc. and showed how these features can be recognized on fired cases. They further showed how pistols divided into these general types, can be further separated into subgroups by a more detailed classification of the various features, and how in some instances, because of certain special peculiarities, the make of the weapon can be established (2). To some of us their findings may seem to be somewhat disappointing, since they fail to completely support what was originally anticipated.

Those of us, now engaged in firearms identification work, should be grateful to Mezger, Heess, and Hasslacher and to all other investigators who were similarly engaged. They did much to clear the atmosphere of an erroneous concept by pointing out limitations that exist. This removed us from the awkward position of defending ourselves for our inability to accomplish the impossible.

Fired Standards

Textbooks and articles in the field of firearms identification almost without exception advise the collection of fired standards. The written material on this matter however, is not always clear and to the point as to the practical use of this collection.

Major General Julian S. Hatcher (3), in his textbook "Firearms Investigation, Identification and Evidence" refers to the importance of such a collection. He (3) states that, "In making this collection of fired cartridges and recovered bullets from known arms, the worker should bear in mind that it is well to have samples from at least two individual guns of each type, so that some idea can be gained of the differences to be expected between guns supposed to be the same." Hatcher indicates that we must evaluate this collection in terms of extent of variation of class characteristics.

Let us suppose that we have a collection of fired standards from all the makes and models of .32 caliber autoloading pistols. This collection consists of pairs of cartridges fired in each weapon. Would we be correct in assuming that these pairs bear class characteristics truly representative of the makes and models of weapons in which they were fired? Investigation of this matter indicates it would be a mistake to assume such a thing.

Well made autoloading weapons, manufactured to strict specifications, will have a tendency to transmit certain markings in a form peculiar to the particular makes and models. However, there is no absolute uniformity in this reproduction. In some makes and models the variations in uniformity might be relatively small and in others considerable.

A pair of tests might bear markings representative of the weapon in which they were fired. On the other hand they might be anomalies if they had been fired in a weapon which had been abused or worked over so that the true class characteristics were altered or obscured by the change.

In view of these facts, the collection of fired standards must be looked upon with a certain amount of reservation. We must assure ourselves that the standards we have are representative of the makes and models before we use them for guidance or reference. All this suggests a study of many fired specimens in order to establish the class characteristics as produced by a weapon, and to determine the degree of uniformity of this reproduction by other weapons of the same model.

Reasons for the Study of Class Characteristics

One might question the value of such an undertaking, if the sole reason for this work was the possible determination of make and model of weapon. While this is not our purpose, we do not deliberately ignore significant facts uncovered which might be useful in such a manner.

In firearms identification work, the identification of a weapon is based on the correct evaluation of similarities of class and individual characteristics. How important is a good knowledge of the class characteristics of a weapon under consideration in establishing an identification? Some may argue that it is relatively unimportant. This is perhaps true if the weapon is of crude make, manufactured under flexible specifications and with basic requirements that it function and resemble its trade-name companions in shape and finish. In weapons of this type one does not anticipate well defined uniformity in the reproduction of class characteristics, because absence of close tolerances in the fitting of miscellaneous working parts is not conducive to such a condition.

The fired cartridge cases usually bear a large amount of detail from the crude finish of the breech-face. When no effort is expended to produce a fine finish of the firing pin,

ejector and extractor, they in turn possess and impart a great deal of individual imperfections. Burrs around the firing pin hole and chamber also add to the individuality of each weapon.

Here the problem of identification is simplified by a tremendous amount of individuality and the absence of appreciable uniformity in the reproduction of class characteristics.

These conditions are reversed when we consider weapons produced under strict specifications, close tolerances and fine fitting of miscellaneous parts. Such weapons tend to reproduce class characteristic markings with a relatively high degree of uniformity, and modern refinements in machining which are usually incorporated in such manufacture, tend to minimize the presence of individual imperfections.

In the identification of weapons of this type, the examiner will have to evaluate correctly the similarities he observes. He will have to treat separately those similarities which are peculiar to the make and model of the weapon, from those which can be ascribed to the particular weapon in question.

In order to avoid any misconceptions, it should be stated that the above describes the two extreme conditions. All autoloading weapons could not be simply divided into either one or the other group. The positions between these two extremes that a particular make and model might occupy is determined by the degree of uniformity in the reproduction of class marks and the extent and usefulness of the individual characteristics.

We would be guilty of omission if we failed to take another factor into consideration. Individual, and to a certain extent, class characteristics do not remain constant after manufacture. Additional individuality is acquired through differences in amount of use, care, or especially abusive treatment. This acquired individuality is very helpful in identification work, but it cannot be always relied upon to exist in sufficient quantity and useful quality in all weapons.

Ejector Mark—.32 Cal. C.Z. Modell 27

For the purpose of illustration we would like to present some findings pertinent to this particular weapon. Let us

take the ejector mark into consideration. Figure 1 represents the basic form of this mark. With the cartridge case oriented so that the mark is viewed in 6 o'clock position,

Ejector mark of .32 Cal. C.Z. Modell 27 autoloading pistol. Example of class characteristic reproduction of basic form of this mark. (Mag. 20X)

the mark is in the form of a half-moon. The build-up of displaced metal is upward and to the left. Its position is on the edge of the rim of the cartridge head. Details in the mark indicate that the action of the ejector is in the direction from rim towards primer.

There is however, a pronounced modification of this basic form as shown in Figure 2. This appears as a double half-moon and predominates in frequency of occurrence over mark

Ejector mark of .32 Cal. C.Z. Modell 27 autoloading pistol. Example of class characteristic reproduction with modifications of basic form shown in Fig. 1 and which predominates in frequency of occurrence with this model. (Mag. 20X)

shown in Figure 1. As a general rule, this is what can be anticipated in the basic form and position of ejector marks by this particular weapon.

Variations in Production of Basic Forms

If faithful reproduction of the basic form of the ejector marks of this model were the rule, we would photographically record the facts and would turn our attention to some other feature of this work. But such is not the case. The basic form is reproduced with certain variations. These variations are in intensity and in the displacement of the mark from rim towards primer.

Marks will vary from ones with deep and well defined outlines to ones where careful observation is necessary to establish the true form.

Study of variations in the position of the mark indicate that these are due to a skidding action. In other words, the cartridge case is not merely forced back to take a smart imprint of the ejector. The action of the ejector is relatively prolonged or continuous and in the direction from rim towards primer, and results in the displacement of the mark accordingly. The formation of the double ridges as shown in Figure 2 seems to result from a type of chatter or jump action during this process. This assumption is based on the fact that specimens were found in which the two ridges were sufficiently spaced apart to produce what seemed to be impressions of double ejector marks.

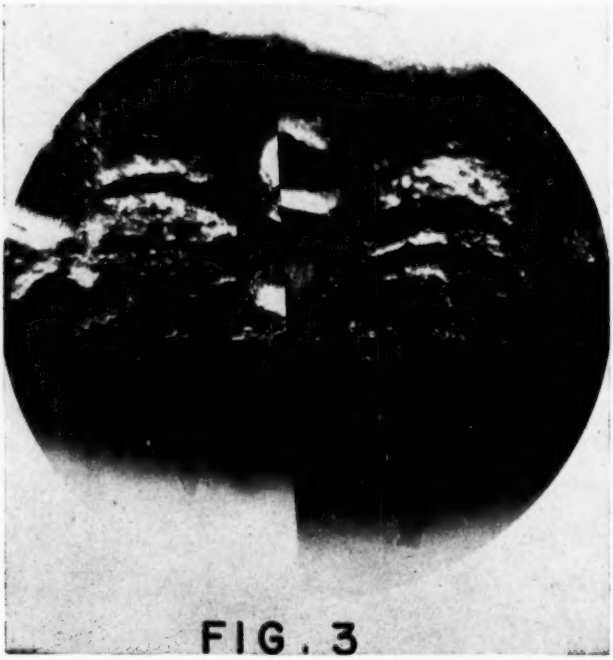
Reproductions of this basic form of ejector marks by two pistols of this particular model are shown in Figure 3. They are shown side by side, and while not identical in detail, demonstrate that reproduction of the basic form, with a certain amount of variation will occur.

Figure 4 illustrates the possibility of similarity in reproduction and displacement of the mark from rim towards primer. Again these are cartridge cases fired in two different .32 Cal. C.Z. Modell 27 pistols.

Extractor Marks—.32 Cal. C.Z. Modell 27

Figure 5 illustrates the basic form of extractor mark as produced by this weapon. With the base of the cartridge case at 6 o'clock the mark appears to the right of a rim cut. It slants to the right and builds up metal into mushroom form up the sloping side of the cannelure.

Variations are primarily in intensity and slight differences in relative position of rim cut and body of extractor mark. In one pair of samples the rim cut was far enough to the right to be in line with the extractor mark.



Two ejector marks by two .32 Cal. C.Z. Modell 27 pistols. Demonstrate possibilities of similarity in reproduction of these marks. (Mag. 30X)

Figure 6 illustrates similarities in reproduction of the basic form of extractor marks with two different pistols of this model.

Figures 3, 4 and 6 demonstrate the possibilities of close reproduction in general form of ejector and extractor marks, by different weapons of the same make and model. They

of course are not identical, but neither are tests fired in the same pistol, since a certain amount of accidental variation is almost always present.

Because of variations in reproduction of class characteristic forms of these marks, as hereinbefore discussed, highly selective specimens were used in these demonstrations.

Two ejector marks by two .32 Cal. C.Z. Modell 27 pistols. Demonstrate similarities in reproduction and displacement from rim towards primer of these marks. (Mag. 30X)

It is fortunate that exact reproduction of class characteristic form is not common. If it were, it would simplify the problem of determining the class characteristics of weapons, but

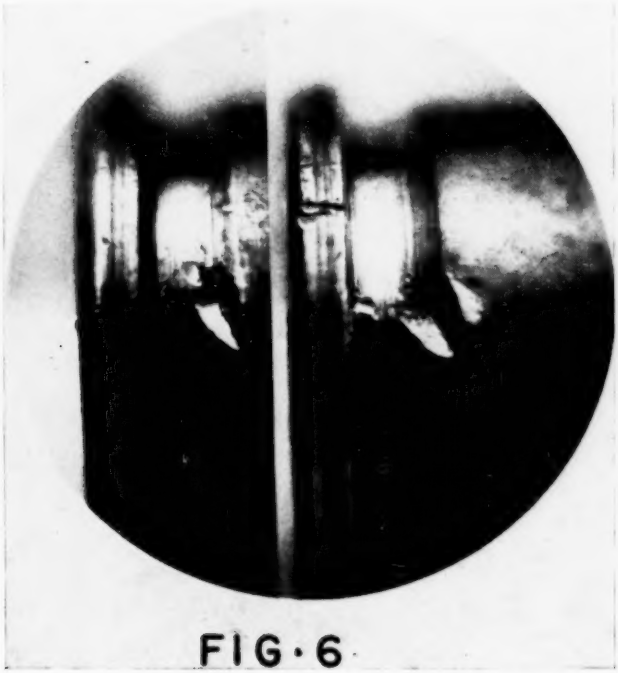
would make the identification of an individual weapon more difficult. When, however, a strong similarity of class characteristic form is present, it must be recognized as that and nothing more. The basis for such a decision will be the

Extractor marks of a .32 Cal. C.Z. Modell 27 pistol. Example of well-defined class characteristic reproduction of basic form of this mark. (Mag. appr. 25X)

knowledge of the tendencies in the reproduction of class characteristics by the weapon in question. Under such circumstances close attention to individual peculiarities present in

these marks is indicated. Figure 7 is a photomicrograph of increased magnification (about 35X) of the specimens in Figure 6.

Outstanding variations in the class characteristic form of markings may be useful in supporting an identification of a weapon. When properly recognized as such, they indicate



FIG·6

Two extractor marks from two different .32 Cal. C.Z. Modell 27 pistols. Demonstrates possibilities of similarity in reproduction of these marks. (Mag. 10X)

a common origin, if examination of a number of tests fired in the weapon shows consistent reproduction of these variations of the basic form.

It would be poor procedure to study similarities demonstrated in Figures 3, 4 and 6 with no consideration for the class characteristic tendencies in reproduction of these marks

by the weapons. For example, if we study Figure 4 simply as ejector marks, we observe a lot of similarity in form and dissimilarity in detail. On the other hand, if we do this

Two extractor marks from two different .32 Cal. C.Z. Modell 27 pistols. This is a photomicrograph of increased magnification (35X) of marks shown in Fig. 6.

with the basic form of what should be anticipated with a .32 Cal. C.Z. Modell 27 in mind, we immediately realize that the marks in all probability are incomplete on the left side,

resulting from interference of the head stamp. We would not be ready to accept them as entire reproductions without further investigation.

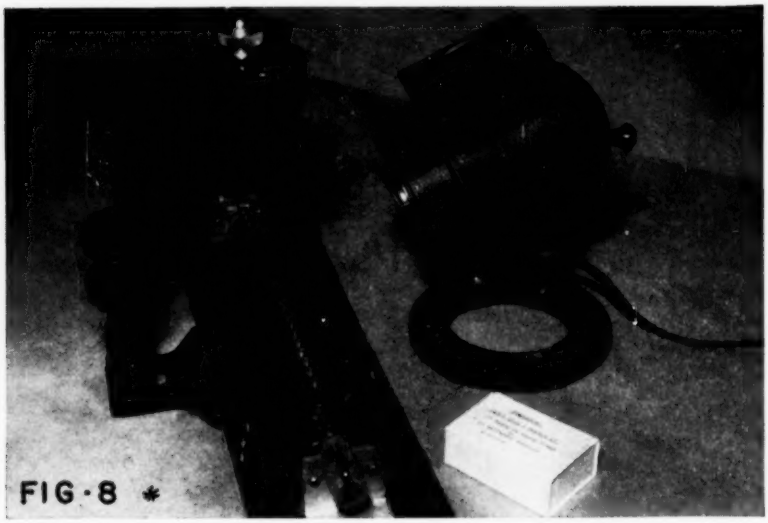
Method of Procedure in the Study of Cartridge Cases

Assume that a decision is reached to make a systematic study of class characteristic reproduction on cartridge cases by a certain weapon. The basic reason for such an undertaking would be a conclusion that a strong tendency towards uniformity in such reproduction is present and merits detailed investigation.

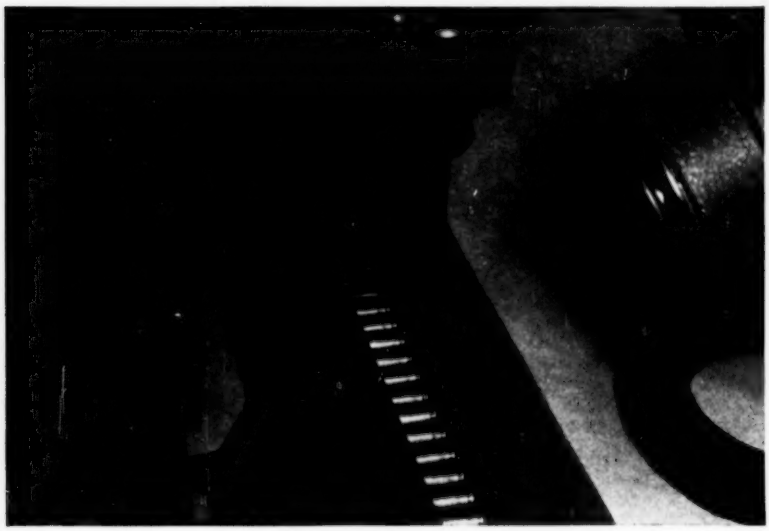
A number of cartridge cases known to have been fired in different weapons of the same make and model are obtained. Two factors decide the number of specimens to be studied: (a) Number available, (b) Number of specimens necessary. In weapons, where the reproduction of class characteristics is pronounced and fairly uniform, a relatively smaller number will establish the necessary facts.

At this point, one has to decide how one is to deal with the problem of dissimilarities possibly attributed to differences in make of ammunition. It is a known fact that the picture will not always be the same when there is a decided difference in the composition of alloys used in the manufacture of cases, primers, bullet jackets, and when there is an appreciable difference in flash hole size and powder pressure. To simplify the problem one should confine attention to cartridge cases of domestic manufacture and of recent vintage even though this would tend to narrow down the findings, and when time and material on hand permit, make a separate study with ammunition of different origin.

We proceed with a preliminary examination of these cartridge cases by using what we, for want of a better name, call a "Scanning Bar." This consists of a square bar of metal supported on ends by two bearings. On the bar there is a series of split brass buttons of the proper size for the purpose of mounting cartridge cases as shown in Figure 8. The bar can be tilted in its bearings so an examination of marks in the extractor groove and on the body of the cases can also be made.



"Scanning Bar" and Base with wide field binocular microscope and cartridge cases mounted for examination.



Close up of "Scanning Bar" with assembly tipped over for examination of extractor grooves.

A Wide-Field Binocular Microscope with about 10X or slightly less magnification is excellent for this work, and at least two specimens should be visible at the same time.

Since the base of the microscope would interfere with the lateral movement of the bar, a platform is fitted over the base to solve this problem. Little or no refocusing is required since the bearings are of equal height from the platform.

A number of cases (25 on our bar) are mounted and rotated into the same relative position. This condition would prevail with all ejector marks at 6 o'clock, or in any other one position suitable to direction of light used.

With this equipment we can pass from one specimen to another by sliding the bar in the field of view and through careful observation try to detect similarities in reproduction of the mark studied. We can easily return to and recheck marks if something significant seems to repeat. Let us say that in the course of this examination we are tentatively satisfied that a certain similarity in form tends to prevail, but is reproduced with a certain amount of variation. To clarify the picture, we will resort to grouping the specimens according to extent of similarity present. We would start on the left with the most outstanding example found, and place to the right of it the next best sample, and continue this process until all specimens are in this order. When this regrouping is properly completed, we are in a better position to formulate an opinion as to extent of similarities and dissimilarities present.

At this point we are trying to determine if certain features of the mark under consideration can be accepted as typical class characteristic reproduction for this particular make and model. Utmost care and good judgment must be exercised in reaching such a conclusion. We must study dissimilarities in this reproduction and decide whether they can be accepted as variations of what we consider as typical or entirely different in character.

When typical class characteristic reproduction is satisfactorily established we would undertake a comparison microscope examination of those specimens in which close reproduction exists. We would want to determine how critical

we would have to be if such similarity existed in a firearms identification problem. We would also give special attention to samples which extensively deviated from the accepted typical reproduction. We would compare such cartridge cases with its companions (others fired in the same pistols) to determine if this variation from typical reproduction was accidental or an individual peculiarity of the weapon.

In conjunction with this study, we would thoroughly acquaint ourselves with the weapon. Establish the origin of the marks studied and the manner in which they were produced. We would try to determine if variations in reproduction can be traced to certain variations in the function of the weapon.

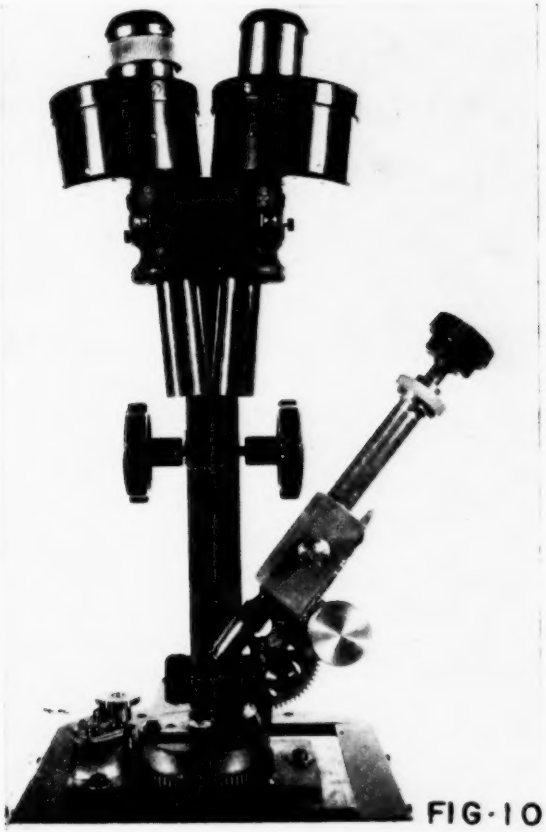
This is a general explanation of the use of this "Scanning Bar." Variations in its use will be dictated by special problems encountered with different weapons. It never replaces the comparison microscope for a true comparison examination. Its primary value is that it makes quick re-examination of characteristics possible without too much dependence on memory.

It is unfortunate that some type of classification system has not been developed to express the results of this study in data form, whereby facts established could be set down with numerical values or expressed in some other manner. Even in the examination of one make and model of weapon it is difficult to express statistically certain findings. It is not always a case of peculiarities being present or absent. For instance, one investigator may decide that the examination of a hundred firing pin indentations disclosed all were of ball point type and that concentric circles were evident in eighty-five specimens. Because these concentric circles varied from very pronounced to mere indications he would want to take note of this variation. At what point is he going to draw the line so as to state, on percentage basis, the presence of well defined concentric circles? He might decide that 67% of them properly fall into this classification. Another might be more critical and decide this matter at a slightly lower figure. While the date of the two might not be identical, both would have a good mental impression of the prevailing reproduction

of this mark as a result of this study. We resort to photography to record peculiarities in form, intensity and location.

Mechanical Stage

Figure 10 shows a mechanical stage for use with a wide field binocular microscope and with a cartridge case mounted for examination. It is particularly useful in manipulating a



Mechanical Stage with Wide Field Binocular Microscope with high inclination of spindle.

cartridge case when the front face of the rim is studied for markings caused by contact with the chamber rim of the barrel. These markings can only be present when chamber permits the cartridge to seat all the way and make such a contact. This type of examination requires a high degree of inclination as demonstrated in this photograph.

This inclination can be varied down to and below the horizontal position shown in Figure 11, which is suitable for

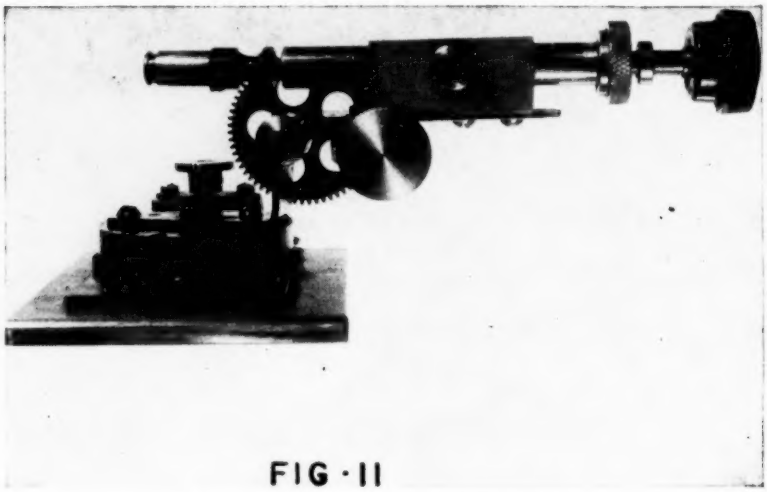


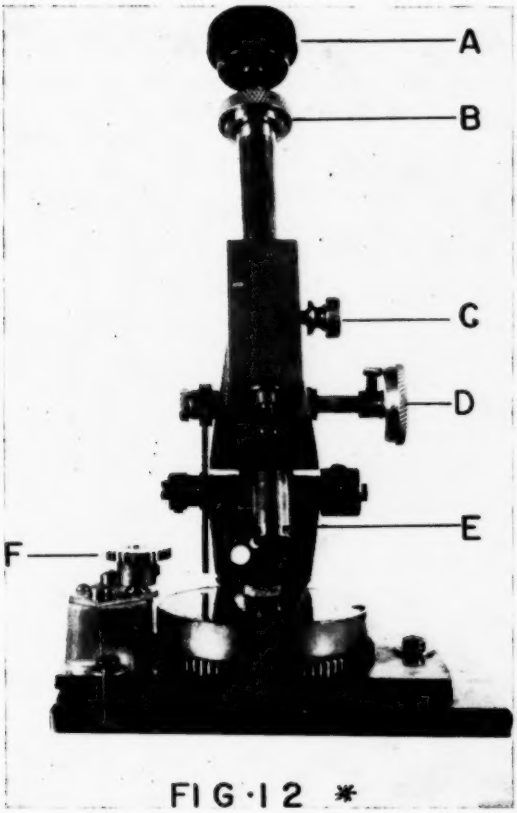
FIG · 11

Mechanical Stage in horizontal position.

the study of ejector groove and body of cartridge case. Its various adjustments make it possible to position the specimen from any desired direction into the exact center of the field of view. Its outstanding feature is that the cartridge case can be rotated on its axis after the desired position has been established.

Figure 12 shows stage in elevated position.*

* The "Scanning Bar" and base, and the Mechanical Stage were produced by Technician Joseph S. Price, of the Scientific Crime Detection Laboratory of the Chicago Police Department.



FIG·12 *

Mechanical Stage in elevated position with controls labeled and described in text of article.

A. Knob used to rotate spindle and cartridge case holder.
B. Spindle sleeve which determines distance cartridge case projects into field of view.
C. Lock for Sleeve B.
D. Control for elevation of assembly.
E. Cartridge case mounted on holder.
F. Knob for rotating assembly in its horizontal plane.

Deviations in Position of Ejector Mark from Extractor Mark

Mezger, Heess and Hasslacher (4) discuss their efforts in regard to the measurements of the central angle formed by the position of extractor and ejector marks for the purpose of using these measurements for subdividing groups in their classification system. They decided that these measurements would not be useful for this purpose, because of extensive variations found.

In spite of these facts, the independent examiner might want to determine the degree of uniformity of a certain pistol in the reproduction of these two marks in this respect.

Several methods were tried and found unsatisfactory. Because the extractor mark is not visible on the cartridge head two optical instruments were used. One, in vertical position, was to fix the position of the ejector mark at zero, and the other, designed to turn about the circumference of the rim, was to locate it on the extractor mark and its relative position expressed in degrees. Another method, a slight variation of the one described, involved the rotation of the cartridge case. Both methods failed to give uniform readings because the difficulties of mounting the cartridge case dead center were not solved.

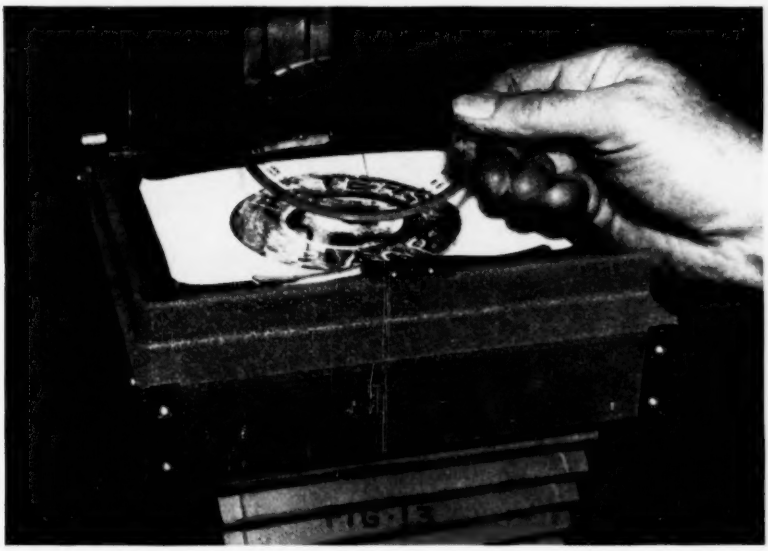
To overcome these problems, we resorted to a very simple procedure. After the study of the extractor marks was completed, and while the cases are still mounted on the "Scanning Bar" as shown in Figure 9, we would make a sharp cut on the rim of each case exactly in line with the main body of the extractor mark. This is done with utmost care and the cuts are coarse enough to be clearly visible.

When these measurements are to be taken on a group of cartridge cases, we set up our vertical L camera with a 32 mm Micro Tessar lens, and with intense illumination from two Nicholas lamps we project the image of the cartridge case on the ground glass. We use a bellows extension of a length, such as to produce an image $4\frac{5}{16}$ inches in diameter and of the exact size of the 360 degree transparent protractor used.

This eliminates the problem of centering and the reading is simply made on the scale after properly locating the center

of the ejector mark and the cut previously made on the rim. We find the standard doublet focusing glass very useful in this operation.

In connection with this examination, another observation which does not require additional effort can be made. Figure 14 shows protractor positioned over cartridge case with ejector mark at zero. The image is divided into four quadrants and variations in the position from center of the firing pin indentations can be noted.



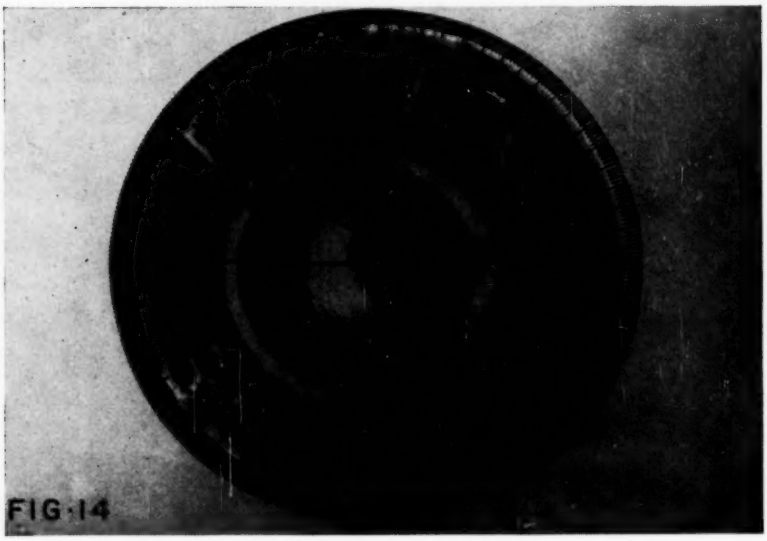
Illustrates image of cartridge case projected on ground glass of L camera and 360 degree protractor about to be placed to measure central angle formed by ejector and extractor marks.

Consideration for Class Characteristic Reproduction in the Identification of a Pistol

The .32 Cal. Beretta Model 1934 is well suited for demonstrating the importance of evaluating similarities and dissimilarities in the identification of this weapon, with proper consideration for the influence of class characteristic

reproduction by this model. The reasons for choice of this particular make and model are as follows:

1. It is a weapon frequently encountered.
2. Reproduction of various marks follows a well-defined class characteristic pattern.
3. Abundance of individual characteristics of breech face impression on cartridge case seldom present.
4. Variations in reproduction by individual weapons of certain marks must be understood and be properly reconciled.



Illustrates protractor over image of cartridge case.

In general, the examination of cartridge cases fired in different pistols of this make and model reveals that one seldom finds a pronounced "thumb print" of the breech face. Abundance of striations and other imperfections usually found with other weapons, and useful in establishing identity, are an exception. Reproduction in form and position of firing pin impression, extractor and ejector marks occurs with a certain amount of uniformity.

Figures 15 and 16 (CM-Chambering Marks, EJM Ejector Mark) are photographs of cartridge cases fired in two different pistols. While not identical, they illustrate a general overall similarity of firing pin impressions, absence of breech face markings, and uniform position and form of ejector marks. They also show a remarkable similarity in distribution of chambering marks.

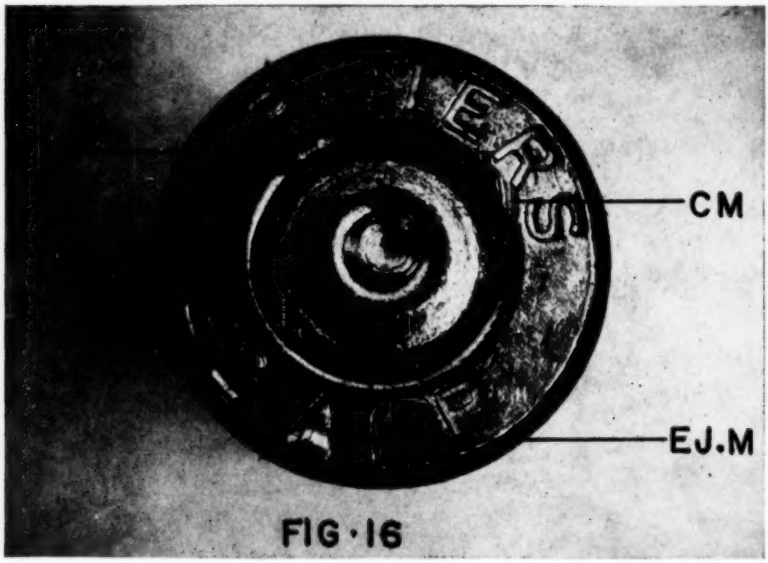
Base of cartridge case fired in a .32 Cal. Beretta Model 1934 CM—Chambering Marks EJM Ejector Mark.

Let us consider the various markings produced by this weapon in the sequence of their occurrence, and in a manner applicable in the identification of the individual weapon. We will disregard such incidental markings as magazine scratches, etc.

Ejector Groove Cuts

The first significant marks to appear on cartridge cases are two parallel cuts on the rim and frequently at the mouth

of the case. Figure 17 shows marks present on right hand cartridge case. They occasionally extend intermittently down the body of the case from rim to mouth. These cuts are



Base of cartridge case fired in a .32 Cal. Beretta Model 1934 CM—Chambering Marks EJM Ejector Mark.

produced by the two edges of the ejector groove in the slide when it is drawn back over the top cartridge in the magazine. These cuts are evenly spaced but extensive variation in intensity is present. These variations in intensity (especially when found on cases fired in the same pistol) are usually the result of wide variations in pressure of the magazine spring. In other words, the top cartridge in a fully loaded magazine, contacts the ejector groove with much more force than the last one, and is more distinctly marked.

The presence of these cuts should always be anticipated, yet it is possible for them to be entirely absent. When not even the slightest trace of these marks is found, one should suspect the possibility that such a cartridge was either hand chambered, or chambered with the slide locked back before

magazine was inserted. By either method the cartridge case would not come in contact with the ejector groove and be marked in this manner.

Two cartridge cases fired in a .32 Cal. Beretta Model 1934 illustrating absence on left case and presence on right case of ejector groove cuts on rim of case. Two extractor marks illustrate typical class characteristic reproduction of this model. (Mag. 10X)

In firing tests for comparison, one follows the rule of duplicating, as closely as possible, the conditions that might have prevailed in the firing of the evidence. In view of what has been previously said about variations in the reproduction of these ejector groove cuts, one is entirely justified in taking into consideration such factors as the number of cartridges in the weapon when confiscated. Let us say the weapon contained six cartridges and ejector groove cuts are present on both evidence cartridge cases. This would

suggest the possibility that a fully loaded magazine was inserted and the slide drawn back to chamber the first cartridge. The examiner would logically follow this procedure in firing his tests. On the other hand, if the weapon contained seven cartridges, and on one of the two evidence cases no ejector groove cuts are present, he would load the number one test by either hand chambering or would lock the slide back before a fully loaded magazine was inserted. Actually the proper one of these two methods would be determined by presence or absence of chambering marks on head of case without ejector groove cuts. This matter is explained in the section dealing with reproduction of chambering marks.

At this point one might inject the various possibilities such as the likelihood of reloading of the weapon after it was used in the crime, previous chambering of more than one time of evidence cartridge cases received, etc. which would tend to cloud up the reasoning behind the methodical operation suggested. These possibilities are always present, and must be dealt with, but are not a valid reason for shelving use of good judgment for haphazard procedure. When reasons for variations are known and can possibly be controlled, it is logical to take advantage of such a situation.

Attempts to match individual stria in the ejector groove cuts is usually not satisfactorily accomplished. The examiner should be satisfied if they are present with uniform intensity, and evaluate them as class characteristics.

Chambering Marks

Chambering marks (CM—Figures 15 and 16) are the second markings produced and at times present a considerable amount of difficulty in comparison work.

The breech face of this particular pistol is milled out so as to form a circular recessed seat for the cartridge head. The bottom portion is split by the ejector groove producing two projecting surfaces. When the slide starts forward, these two projections contact the top of the head of the cartridge and strip it from the magazine and into the chamber. The head of the cartridge is forced to rise as it is pushed forward by these two projections, and this results in markings to the left and to the right of the primer.

The following general statement can be made as to their locations. When the cartridge case is viewed with ejector mark in 6 o'clock position, the locations of these marks, predominates in frequency of occurrence in the upper left and right portions of the cartridge head. Frequently chambering marks are also found in both bottom quadrants. The striations in these marks tend to be in a vertical direction.

These chambering marks are very individual in detail, but are frequently reproduced on cases fired in the same weapons, with extensive variations in intensity, location, direction and even in sudden changes in direction within the marks themselves.

Tests were conducted to determine the extent to which position of cartridges in the magazine might be correlated with these variations. It seemed logical that the cartridge stripped from a fully loaded magazine would offer far more resistance than the last one, and would be more intensely marked. This would at least account for variations in intensity. This assumption was not satisfactorily verified. It is possible that our investigation was not extensive enough to establish a connection. A more probable explanation of these variations in reproduction of these marks might be ascribed to the combination of these changes in spring tension of the magazine, and the fact that in chambering, a cartridge has a certain amount of freedom to twist and otherwise change position while in transit from magazine to chamber. Variations in proper alignment with the chamber, requiring that the cartridge make sudden changes in direction to enter properly, may be another added factor.

In the comparison of many cases, fired in pairs in different weapons, the examiner will formulate an opinion as to the possible extent and character of these variations. This will be the basis for reconciling these dissimilarities in reproduction when encountered in identification work. The examiner will first definitely establish that these characteristics are chambering marks, and accept this as indicative of the make and model. He knows that uniform reproduction here cannot always be anticipated and that a certain amount of latitude in dealing with these dissimilarities is permissible. He knows that in spite of these variations, a significant

similarity in number, peculiar texture and formation of striations within these marks, can be properly evaluated as indicating the weapon in question.

He cannot allow himself such liberty in judgment in the comparison of actual breech face impressions. Let us take into consideration the extreme condition which might prevail if a weapon produces outstanding chambering marks with a considerable amount of variation from shot to shot, and also prints an appreciable amount of breech face imperfections. To examine both of these types of marking jointly, would result in a confused picture of similarities and dissimilarities. The examiner will certainly treat these two classes of markings separately. He might, in order to be sure he differentiates between them properly, compare a cartridge case which was hand chambered and fired, with one loaded through the magazine in the conventional manner. The first would bear a breech face impression only, and the second chambering marks in addition to the breech face impression.

In proceeding in this manner, the examiner will establish that a significant similarity of individual characteristics is present in both of these classes of markings. He will properly reconcile certain dissimilarities in the chambering marks through judgment, based on his knowledge of the weapon's peculiar tendencies in the reproduction of these marks.

At times, some cartridge cases will bear a narrow band of fine vertical striations along the circumference of the cartridge head in the vicinity of 12 o'clock. These also result in chambering, and are mentioned because there is a tendency for faithful reproduction in these striations. They are therefor useful in supporting an identification of the weapon.

Firing Pin Impressions

The prevailing tendency of the .32 Cal. Beretta Model 1934 is to produce ball point impressions with concentric circles (varying from those heavy in texture to mere indications) with an appreciable amount of irregularities in the surface. Exceptions to this general rule in a relatively small number of instances was absence of concentric circles, and in three specimens out of fifty examined, a circular flat impression was noted.

The firing pin impressions present no problem in firearms identification. Comparison of cartridge cases fired in different weapons revealed that extensive variations in size, depth, amount and texture of concentric circles and irregularities in the surface prevailed from gun to gun. Comparison of these cartridge cases with their companions (others fired in the same respective weapon) revealed that uniform reproduction of these peculiarities was the rule. It is therefore proper to evaluate these peculiarities as highly significant for identification purposes.

Primer Surface. The prevailing tendency observed was a raised and frequently very rough surface around the firing pin impression, with varying amounts of flow back ending in unusual shapes. Concentric circles and parallel striations, varying greatly in texture, were frequently found around the outer edges of the flow back. No flat primers were found.

Comparison procedure, as outlined in the study of firing pin indentations, was carried out and revealed these peculiarities and distinctive geography to be highly individual.

Extractor Marks. Because extractor marks are found in the vicinity of the ejector groove cuts, one may be concerned with the relative location of these marks. Facts established in the study of this feature are as follows:

1. The predominating tendency was to produce extractor marks between the two cuts as shown in Figure 17.
2. Variations in position were to the left and to the right, and even outside of the area between the two cuts.
3. These variations in relative displacement are not uniformly reproduced on cases fired in the same weapons.

This absence of uniformity is understandable if we consider the sequence in the production of ejector groove cuts and extractor marks in the cycle of operation. The ejector groove cuts were produced by the slide before the cartridge was stripped from the magazine. In chambering, the cartridge can twist slightly in either direction, and will not uniformly locate the ejector groove cuts in the same relative position with the extractor hook.

While the extractor may produce markings on the case as it comes in contact with same in loading or on the rim as it

overrides same if cartridge is hand chambered, the important and distinct extractor mark occurs when cartridge is fired and suddenly backs up under the extractor hook.

In view of these facts, the examiner will not allow variations in the relative locations of extractor marks and ejector groove cuts to be a major concern, but on the other hand, will not consider uniformity in reproduction if present, as individual traits of the weapon.

Figure 17 illustrates the typical form of extractor marks usually reproduced by this model, and merely indicates that good class characteristic reproduction is present. Such reproduction is not significant in identification of the individual weapon unless supported by similarity in peculiar details in the structure of these marks.

Variations in reproduction of this typical form are frequently found. Usually they are in size of mark, intensity and in position on the sloping side of the extractor cannelure. These variations from typical class characteristic form are frequently very significant, because it was established that this model tends to reproduce extractor marks (whether typical or not) with a high degree of uniformity.

Ejector Marks. With the cartridge case oriented so that the extractor mark and slide cuts are at 12 o'clock, the ejector mark is found in 6 o'clock position. The prevailing tendency is to produce the mark about midway from rim to primer, but variations in either direction from this central position occur.

Figure 18 illustrates ejector marks by two pistols. The left cartridge case shows the typical reproduction of this mark as a horizontal impression. The right cartridge case illustrates the extent of variation possible in the form of the mark and in its displacement.

Cartridge cases fired in pairs in different weapons were compared to determine extent of uniformity in reproduction of these variations in form and displacement. The following conclusions are based on this study. Individual weapons tend to displace the marks from the accepted central position with a fair degree of uniformity. In like manner, variations in the shape and structure of these marks from the typical

reproduction by this model, were also found to be individual peculiarities of the pistols in which they were fired.

Two ejector marks by two different .32 Cal. Beretta Model 1934 pistols. Left mark illustrates typical class characteristic reproduction. The right mark illustrates possible variation in form and position. (Mag. 30X)

For the purpose of identification, similarity in reproduction of these ejector marks must be evaluated according to extent of their variation from the typical class characteristic pattern established for this weapon. The more unusual they are in this respect, the more significant they are in supporting the identification.

Incidental Marks. The investigator should be on the lookout for certain incidental marks which at times are present and are useful in supporting the identification of a pistol. An

example of such marks is seen on the lower part of the forward edges of the rims of cartridge cases shown in Figure 17. They were caused by defects in the chamber rim of the weapon. These marks, when found, reproduce in the same relative position with the extractor mark, but will differ in this respect in relation to the ejector groove cuts.

Figure 19 is a comparison photomicrograph (30X) of pivoting marks on rims of cartridge cases fired in the same pistol,

Photomicrograph of a comparison of pivoting marks on cartridge cases fired in the same .32 Cal. Beretta Model 1934 pistol. (Mag. 30X)

and illustrates possible uniformity in reproduction of striations in these marks. They were produced in the twisting out from under the extractor hook in ejection.

Possibilities of Changes in Class Characteristic Reproduction

The examiner must anticipate possible changes in manufacture which might result in a different reproduction of class characteristic form of some mark and guard against acceptance of such a variation as an individual peculiarity.

Such a change was found in the 45 Cal. Colt Commander Autoloading Pistol. Figure 20 shows ejector marks on two

FIG · 20

Illustrates change in position and form of ejector marks. Left cartridge case fired in a 45 Colt M 1911–A1 and the right in a 45 Colt Commander. (Mag. 10X)

cartridge cases photographed in the same relative position. The left case was fired in a 45 Colt M 1911–A1 and the right in a 45 Colt Commander. On the left case we see a rather typical well defined ejector mark (they occur with consider-

able amount of variation) in the usual position for this weapon. On the right cartridge case the mark is high (about 9 o'clock) very unusual and next to the primer. While only five 45 Colt Commanders were available for examination to date, they uniformly reproduced similarity of this form and position.

Examination of the 45 Colt Commander reveals ejectors are set higher and closer to the center and project considerably over the magazine well.

Summary

In the first part of this article we tried to demonstrate the extent and possibility of close reproduction of various marks by different pistols of the same make and model. The basis for recognizing these similarities as being class characteristic in nature, depends strictly on the examiner's intimate knowledge of the weapon and its tendencies in this respect.

Since a study of this kind requires the comparison of many fired specimens in order to form a concept of what is to be anticipated, we briefly described the manner in which we undertake such a study, and some of the specialized equipment we found useful for this purpose.

In describing the peculiarities of the .32 Cal. Beretta Model 1934, we tried to demonstrate: (1) the importance of a good understanding of the weapon and its tendencies in class characteristic reproduction of the various pertinent marks in firearms identification; (2) when uniformity in reproduction is to be anticipated, and when variation is acceptable; (3) how absence of faithful reproduction can be satisfactorily reconciled. We tried to show how proper evaluation of similarities in form should not always be based on extent of similarity present, since this similarity is not very significant when it follows the typical reproduction of the make and model of weapon. How, on the other hand, it is very significant when it extensively deviates from class characteristic form, but is established to be an individual trait of the weapon.

We are not presenting a new concept in Firearms Identification. Our efforts are rather to emphasize the importance of this study and the importance of its application in the

identification of a weapon which demonstrates strong tendencies in reproduction of markings along a well defined class characteristic pattern.

It is assumed that the experienced examiner would not merely concern himself with similarities and dissimilarities present, with no regard as to what extent reproduction might be influenced by make and model of weapon. It would be like describing in detail, or attempting to identify a certain person without first taking into consideration that he is an Eskimo. One certainly would not judge his color, hair, features, size and structure with no regard as to what extent these characteristics were racial traits.

It is immaterial whether one acquires this knowledge of class characteristic reproduction through a formal study as described in this article, or through observations during the course of time spent in routine work and many investigations. It is however, very important that this knowledge is properly applied so that the identification of a weapon is truly based on similarity of class characteristic reproduction present and on similarities positively established to be individual characteristics.

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Potassium Levels in Cerebrospinal Fluid and Their Relation to Duration of Death

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Introduction

Over one hundred years have passed since Letheby (1) introduced to criminal investigators the role of body temperature in the estimation of time of death. Keith Simpson in an address to The Society of Medical Jurisprudence (2) decried the lack of development of a more practical and accurate test in this important field. Schourup in his excellent monograph on the determination of time of death by the quantitation of lactic acid, amino acids and non-protein nitrogen in cisternal fluid (3) lists the advantages of chemical analysis over the factors usually taken into consideration at the postmortem table.

During the past three years while engaged in the flame photometric determination of metals in the cerebrospinal fluids of cancer patients both pre- and postmortem, we noted a consistent relationship between duration of death and the level of potassium. Because of the obvious need in medicolegal necropsy investigation for a simple, exact and practical test to pinpoint the time of death, we undertook the following investigation.

Method

The chart temperature at time of death and the pre-necropsy environmental temperature were recorded. The body

* From the Department of Pathology, St. Mary's Hospital, Orange, New Jersey (Cancer Research Laboratory).

was positioned on the left side on a level surface at a right angle to the surface of the table. The head rested on a block six inches above the table in a normal anatomic position. A chemically clean thoroughly dry 18 gauge 3 inch spinal needle was introduced into the cisterna magna and the first five drops allowed to pass. (The analysis of spinal fluid was abandoned early in the study because of the obvious divergent gradient of diffusion from that of the cisternal fluid, i. e., cases #38 and #42.) The subsequent 5 ml. were collected in a chemically clean, dry centrifuge tube, immediately centrifuged and the clear supernatent separated from the sediment. If not immediately analyzed the supernatent fluid was stored in a refrigerator at plus 4° centigrade.

Flame photometric quantitation of Mg, Ca, Na and K was accomplished with the Beckman Model DU Spectrophotometer with Flame Attachment following the principles outlined by Overman and Davis (4) and Mosher et al. (5 and 6) with our own modifications for equilibrating potentiation and quenching (7).

Results

Forty-six cases ranging from 2 to 24 hours after death were analyzed. The essential data relating to each case are listed in Table I. A graphic representation of potassium level and postmortem time is depicted in Graph I.

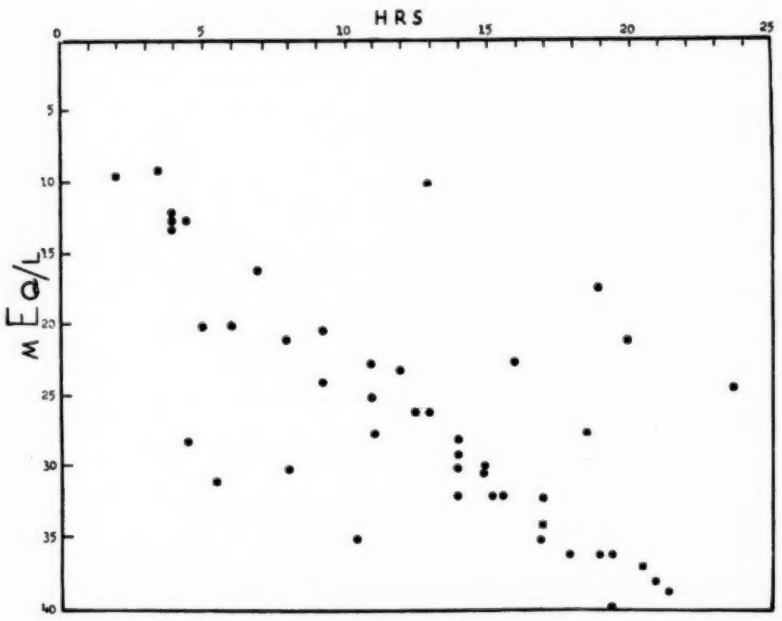
Discussion

From this preliminary study it would appear that there is a constant rate of diffusion of the K ion into the cisterna magnum and that it occurs in a straight line gradient which is unrelated to the age of the deceased. In contrast, the other three metals studied have a complete unpredictable manner of diffusion. The rate is consistently affected by the temperature of the body at time of death (i. e., case #6) and subsequent environmental exposure (i. e., case #21). Heat accelerates and cold decelerates the process. Severe infections or toxic processes existing for an extended period prior to death also influence the subsequent rate of diffusion (i. e., case #15). An interesting supposition is the possible existence

TABLE I

Case No.	Sex	Age	Diagnosis	Postmortem Time (Hrs.)	Temperature At Death	Temperature Environment	K mEq	Remarks
1	M	17	Encephalitis	2	100°	72°	9.5	Viral etiology?
2	M	64	Ruptured Aortic Aneurysm	3½	98°	75°	9	None
3	M	35	Coronary Artery Disease	4	98.8°	70°	10.2	Congestive heart failure
4	M	19	Acute Glomerulonephritis	4	98°	75°	13	Serum K 7.6 mEq 1 day before death
5	M	50	Coronary Artery Disease	4½	98.6°	60°	12.5	None
6	F	32	Chronic Hepatitis	4½	102°	65°	28	Obese; intense jaundice
7	M	74	Coronary Artery Disease	5	101.6°	75°	20	Had been decompensated for some time
8	F	59	Cerebral Hemorrhage (apoplexy)	5½	105°	72°	31	Cisternal fluid xanthochromic with many rbcs
9	F	88	Bronchopneumonia	6	104°	50°	20	Arteriosclerotic cardiovascular disease
10	M	67	Bronchogenic Carcinoma	7	99°	74°	16	Lung resected several months before death
11	M	58	Pulmonary Embolus	8	99°	75°	21	Deep phlebothrombosis of leg
12	M	74	Arteriosclerotic Heart Disease	8	100°	68°	30	Marked failure; Serum K 4.1 mEq before death
13	M	54	Pontine Hemorrhage	9	98.6°	70°	20.4	None
14	M	36	Acute Hepatitis	9	96°	60°	24	Sick for 1 week
15	M	12	Bronchopneumonia	10½	103°	74°	35	Fluid xanthochromic
16	M	50	Lobar Pneumonia	11	101.6°	65°	22.5	Empyema superimposed
17	F	43	Coronary Artery Disease	11	100°	75°	25	Exact temperature at death not recorded
18	M	70	Chronic Hepatitis	11	99.4°	75°	27.5	Jaundiced
19	F	32	Septicemia	12	100°	74°	23	Complicating pregnancy
20	F	2½	Bronchopneumonia	12½	100°	60°	26	None
21	M	67	Coronary Artery Disease	13	99°	42°	10	Refrigerated; old infarct and recent thrombus

22	M	67	Arteriosclerotic Heart Disease	13	99°	70°	26	Treated for heart disease for some time
23	M	42	Cerebral Hemangioma	14	101.6°	75°	27.5	None
24	F	57	Coronary Artery Disease	14	98.6°	65°	29	Had been in failure a long time
25	M	1	Bronchopneumonia	14	100°	76°	30	Exact temperature at death not recorded
26	M	36	Cerebral Thrombosis	14	98.8°	68°	32	No hemorrhage
27	F	72	Bronchopneumonia	14	99.6°	75°	32	Following orthopedic surgery
28	M	72	Spinal Cord Tumor	15	98°	60°	29.8	Extension into vertebrae
29	M	61	Coronary Artery Disease	15	99°	80°	30.2	None
30	M	75	Coronary Artery Disease	15½	99.4°	65°	32	None
31	M	63	Coronary Thrombosis	15½	98.4°	70°	32	Old infarct present
32	F	7	Bronchopneumonia	16	102°	75°	22.5	Associated inanition and fatty liver
33	F	55	Coronary Artery Disease	17	99°	80°	24	Long term cardiac
34	M	78	Coronary Thrombosis	17	99.2°	78°	32	None
35	M	41	Coronary Artery Disease	17	98.4°	70°	35	Had been decompensated for some time
36	F	62	Coronary Artery Disease	18	99°	72°	36	None
37	M	62	Bronchogenic Carcinoma	18½	100°	70°	27.5	Right sided failure with cardiac cirrhosis
38	M	52	Diabetes Mellitus	19	100°	75°	17.2	Spinal fluid
39	M	75	Coronary Artery Disease	19½	99°	65°	36	None
40	M	58	Hypertensive Heart Disease	19½	98.4°	82°	36	Cardiovascular syphilis
41	M	76	Cerebral Thrombosis	19½	99.6°	65°	40	No hemorrhage
42	F	70	Dissecting Aortic Aneurysm	20	99°	75°	21.5	Spinal fluid
43	M	47	Coronary Artery Disease	20½	98.6°	68°	37	None
44	M	72	Coronary Artery Disease	21	98.6°	60°	38	Long term cardiac
45	M	45	Coronary Artery Disease	21½	98.4°	60°	38.7	Complicating rheumatic heart
46	M	54	Cerebral Thrombosis	24	99°	72°	24.5	Spinal fluid; "stroke" 7 years ago



Graph I

of high levels before death in some clinical conditions which may influence the course of the disease.

Assuming that in most medicolegal cases the temperature of the body would be normal at the time of sudden death, the only factors affecting the diffusion of K would be the time elapsed since death and the temperature of the fluid at the site of diffusion from the endothelial cells; this latter factor being under the direct influence of the environmental temperature.

If the above be true, then a direct measurement of the temperature of the fluid (by means of a potentiometer) at the time of withdrawal and the determination of K level in the sample together should give a close estimation of the duration of death. The authors anticipate the extension of this study to include a series of cases exposed to rigidly controlled hot and cold environmental temperatures to more accurately determine their effect in diffusion and possibly develop an

equation which would mathematically relate the factors involved.

Summary

The cerebrospinal fluids of forty-six unselected hospital cases were analyzed for Mg, Ca, Na & K levels. The amount of K increased at a constant rate in relation to the time of death and the temperature of the body. It is suggested that the determinations of cisternal fluid K and temperature may be helpful to criminal investigators charged with the often frustrating responsibility of estimating how long someone has been dead.

The authors wish to thank the St. Mary's Hospital Cancer Council which supplied the equipment by which this research problem was accomplished.

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Chromatographic Analysis of Inks*

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Chromatography as applied to ink differentiation and identification is a rather loose term used to describe a variety of processes for separating the colored and colorless components of ink. In most cases the separation is accomplished by an adsorbent medium such as filter paper or talc, towards which the ingredients show varying affinities. However, for purposes of this discussion, a broader interpretation will be placed on the term to include the process of reliquifying the ink on the document itself for analysis of the resulting color stain. Neither of the above procedures, however, should be confused with the old qualitative method for determining class differences by testing for iron content, etc. A still newer process termed electrophoresis, utilizing an entirely different principle of separation, offers even wider vistas to the inquisitive ink researcher. Space does not permit discussion of this highly technical and interesting process.

The following discussion is not intended as an exhaustive treatment of chromatography but more as a survey of the better known methods in use today by questioned document examiners. Needless to say, interested examiners should conduct their own experiments and only apply chromatographic methods to actual cases when they have tested countless ink problems and educated themselves thoroughly on the subject. Like other scientific fields, there are many pitfalls to be avoided and many questions that cannot be answered definitely. For example, while chromatographic differences

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may in some cases enable the document examiner to state definitely that two inks are not the same, a similar appearing chromatogram will not usually prove identity, since presumably other inks by the same manufacturer would produce the same results. Then, too, minor differences may be apparent on two or more chromatograms which require careful interpretation by the document examiner who must decide whether they are fundamental or superficial.

Disk Chromatography. Many industrial uses of chromatographic analysis contemplate testing of relatively large amounts of solution and accordingly a columnar arrangement into which is packed a suitable adsorbent is found to be the most desirable method. The dilute solution to be tested is filtered or percolated through the adsorbent, creating, as it progresses down the length of the tube, bands of color or chromatograms. This is frequently followed by a solvent which increases the development of the separate zones of colored and colorless material.

For purposes of testing inks on documents, however, where damage to the ink strokes is to be avoided, only a small amount of dried ink is available for testing purposes. This limitation of testing material places the document examiner at a considerable disadvantage; however, a process employing a thin film of adsorbent on glass often produces excellent results which may on a small scale approximate those resulting from testing of the actual liquid inks. This process is known as disk chromatography and is probably the best method devised to date to test small amounts of dried ink without excessive damage to the document.

Godown (1951) (1) reported success using the following method, and the writer has likewise tried this procedure with good results—

> A suspension or slurry of talc (magnesium tetrasilicate) in water is first prepared in a glass eye-dropper type of bottle using a ratio of 5 parts water to 1 part talc by weight. This mixture is vigorously shaken and then applied by means of a dropper to a 2 x 2 glass slide, the dropper being kept in motion until a circle about 1½ inches in diameter is obtained. Spraying the solution on

is another useful method of obtaining a thin film. The desired goal is to obtain a thin film of talc while at the same time avoiding bubbles, striations or defects in the surface. Shaking or gently inclining the slide from one side to the other or gently knocking against a hard object tends to settle the mixture in an evenly distributed film. The talc is then allowed to dry for a period of time, following which it is ready for chromatographic use.

In testing actual ink strokes, Godown (1) suggests applying a small drop of solvent such as distilled water or other agent to an unimportant ink stroke on the document. This is done by means of a small 00 spotting brush. When this solvent has sufficiently penetrated the ink (30 seconds to one minute), the same spotting brush completely discharged of any liquid is used to recover by capillary action the drop of solvent with its accompanying charge of ink. This drop is then applied to the center of the adsorbent medium which quickly takes up the solution. At this point a small chromatogram may be produced.

Immediately thereafter the brush is again dipped into the solvent and applied to the central portion of the chromatogram which then usually increases in size and in separation of the zones of color. In some cases two, three, or more applications of the solvent are necessary to achieve proper separations of the colored and colorless constituents of the ink. In that regard it should be noted that examination under ultra violet light is often helpful in creating a fluorescent differentiation of those zones which may appear colorless or nearly colorless to the naked eye. Viewing by transmitted light may also be of aid.

In order to eliminate the possibility of coloring matter in the paper itself affecting the results, a separate chromatogram should also be made of the paper surface.

Following completion of the chromatogram, further tests are still possible using the standard reagent tests for iron and other constituencies of the ink. Since the adsorbent medium is quite susceptible to damage, application of the reagent by spray is more desirable than by applicator. For example, acidified potassium thiocyanate sprayed on the

chromatogram with a DeVilbiss nasal type spray often works very effectively, and produces a brick red color in the zones (usually outer) containing the invisible iron salts. Manifestly, many varieties of the above described procedure may be employed to good advantage. As a substitute for talc, alumina, powdered asbestos or magnesium oxide may work to advantage on certain specific problems.

Fearon (2) suggests an interesting modification of this procedure whereby several coatings of adsorbent are applied to the glass. Following formation of the chromatogram, the upper coating is removed by shaking the slide, leaving the colored zones imprinted on a transparent base. This procedure permits examination by transmitted light or in a projector. The usual type of chromatogram can and should also be examined by transmitted light, although the adsorbent somewhat intrudes upon the purity of the colors. The process advocated by Fearon (2) is as follows:

Coating

#1 100 ml. distilled water; 25 ml. sodium silicate solution.

#2 50 ml. distilled water; 10 minims hydrochloric acid. After mixing #1 and #2 separately, combine the two by mixing rapidly.

#3 50 ml. distilled water; 10 ml. aerosol, and then combine #3 with that produced by #1 and #2, stirring rapidly.

} Forms silicate gel

Apply two coatings of the mixture (1-2-3) to a glass plate, the second coating being applied after the first is dry.

Spreader

1 tablespoon of asbestos powder (adsorbent) and ¼ teaspoon powdered sugar (binder) mixed in four ounces of distilled water.

Application

Immerse for an instant the dry coated plate in distilled water, and while wet apply evenly the spreader. When the glass with the spreader is dry, it is ready for an ink test. Apply the coating and the spreader with a brush about the diameter of a pencil.

Williams (3) suggests that the slide holding the adsorbent medium be covered with a second glass covering into which has been drilled a small hole. This procedure not only permits a rather rapid development of the chromatographic

image, according to the author, by retarding evaporation, but also tends to shield from damage the adsorbent and chromatogram.

Other means of removing the ink for testing may be employed in cases where court approval has been given. For example, a fine bladed instrument is often useful in scraping off portions of the ink line for testing, as is a fine sharp punch such as that sold by leather hobby shops which actually removes a circular area of the ink. In these cases the dried ink is then placed in the center of the adsorbent and the solvent applied directly to the dried ink.

Experiments with solvents such as water containing a small amount of HCL, ether, or benzene, may effect release of materials that do not respond to other solvents. Instead of a brush, a fine pipette or capillary tube may be used in applying measured drops of solvent to the ink strokes.

In any event, the inquisitive researcher should experiment with many different procedures in order to arrive at one that he feels best suits his requirements.

Chromatography Using Filter Paper. The use of filter paper as a medium for separating ink components was reported as early as 1914 by Schluttig (4). It wasn't until thirty-five years later, however, that the principles established by Schluttig were put to practical use in testing inks.

In early 1950, Fearon (2) described some of the work he had done on this subject and enthusiastically suggested that it was the forerunner of an entirely new method for examining inks. In 1951 and 1952, Souder and Sommerford (5) reported success in differentiating or identifying inks by filter paper chromatography. The mechanics of the procedures used were approximately the same:

> A solvent such as distilled water was placed on a segment of the ink line by means of a glass rod applicator. The solvent was allowed to remain in contact with the line for two to three minutes, following which the edge of a narrow strip of filter paper was applied to the liquefied ink stroke. The liquid contents diffused into the strip of filter paper, at the same time separating into bands of

color due to the different adsorptive affinities of the various components of the ink.

Again, as in the disk chromatography method, it is possible to use a variety of solvents, some of which will undoubtedly produce superior results over others.

As a substitute for filter paper, Edwin Fearon utilized lengths of cotton thread as an adsorptive agent and on which he achieved clearly defined chromatograms.

Color Stain Chromatography. Somewhat akin to the aforementioned processes but not dependent upon the same physical-chemical reactions is the forming of a color stain by reliquefying the ink and bleeding it onto the actual paper itself. Schmitt (6) has used this method of testing inks for many years. Mr. Schmitt suggests that court permission be obtained to use at least three different solvents should one or the other prove ineffectual. The primary ones suggested are distilled water, 5% citric acid or acetic acid—the solvent is applied with a ⅛″ glass rod, a drop being applied to the ink stroke allowing it to dry without blotting. The color stain thus formed is termed by Schmitt "a chromatogram." Schmitt (6) suggests using the figure "I" or other down stroke letter, since this stroke is more likely to have a full charge of ink.

In cases involving old inks on documents, this method of producing color stains on the document itself may be the only practicable one for testing the inks. In a Canada will involving an old document, the writer found that it was impossible to dissolve enough ink for disk chromatography or filter paper chromatography; however, it was possible by Schmitt's method to secure a color stain which was successful in differentiating some inks and identifying others as being of a similar kind. In that case a 2% solution of HCL in distilled water was used, which effected release of the dyes, held in tight bondage due to extreme age of the instrument.

As a general statement regarding the effectiveness of these three main processes on actual ink cases it could be stated that black inks, which are usually made up of several dyes, produce the most vivid and unique chromatograms. Blue

washable type inks may also produce distinctive chromatograms due to the use of different dyes. In some cases a single dye may separate out into two different zones, indicating that the dye itself was not homogeneous. Blue-black inks at the present time are the most difficult to differentiate, although this is not true in all cases.

Summary

The foregoing represents some of the noteworthy work that has been done in this comparatively new field of chromatographic analysis. This is only the beginning and undoubtedly future research will produce better and more effective methods which may enable the document examiner to not only differentiate ink definitely but to identify inks more certainly.

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The Value of Anti-H Reagents (Ulex Europaeus) for Grouping Dried Blood Stains*

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In a previous paper (1), the limitations of blood grouping tests on dried blood stains were discussed. While fresh blood can be tested for as many as 30 different blood factors, once blood has dried reliable results can be obtained only in tests for the A–B–O groups. Moreover, even tests for the four A–B–O groups on dried stains have serious limitations. In practice, such stains are often on soiled garments or other soiled articles, so that the presence of sweat, bacteria, and dirt interfere with the reactions. Even under ideal conditions, the subgroups of A introduce difficulties, so that subgroup A_2B cannot as a rule be distinguished from group B. The isoagglutinins are relatively labile, and when they are no longer demonstrable, sole reliance must be placed on the absorption test for agglutinogens. When testing dried blood stains by the absorption method, it frequently is difficult to distinguish between subgroup A_2 and O.

In general only positive reactions are significant, since negative results may be due to failure of the tests, because of denaturation of the dried blood stain (2, 3). Therefore, if in the absorption test, a stain fails to neutralize the anti-**A** and anti-**B** reagents, a diagnosis of group O is not permis-

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sible, unless one can show that failure of absorption was not due to denaturation of the stains, or to the presence of insufficient stain, or the use of an excess of reagent. If a stain neutralizes the anti-**A**, but not the anti-**B** reagent, a diagnosis of group A is generally justified, assuming that the adjacent unstained material does not react with the reagents. Similarly, a stain that neutralizes the anti-**B** but not the anti-**A** reagent presumably contains group B blood. The absorption test for group A and group B stains has an internal control, so these two groups can be diagnosed reliably, as a rule. On the other hand, group A_1B stains would be expected to neutralize both anti-**A** and anti-**B** reagents. In practice, however, when neutralization of both reagents is observed, the diagnosis of group AB is not permissible, because of the possibility of nonspecific absorption due to contamination of the stain with bacteria or dirt.

In summary, therefore, when the absorption technique is used for grouping a dried blood stain, group A and group B stains can usually be diagnosed reliably, but, group O and group A_1B stains cannot be diagnosed with certainty because of the lack of an internal control. Wiener (2) found that by using anti-**O** reagents prepared from normal bovine sera, the desired internal control could be provided, since group O stains neutralized such reagents while group A_1B stains do not. Unfortunately, anti-**O** reagents prepared from bovine serum do not always give clear cut reactions, and therefore are not suitable for medicolegal use. Recently, it has been found that saline extracts of certain seeds (4, 5, 6) give reactions similar to those of anti-**O** serums prepared from animal blood. As suggested by Morgan (7), such reagents have been designated anti-**H**, because they, as well as so-called anti-**O** serums, do not react exclusively with group O blood cells. Anti-**H** reagents react with almost equal intensity with cells of group O and subgroup A_2; group B cells are less strongly clumped, while A_1 and A_1B cells give negative or weak reactions. Anti-**H** reagents prepared from seeds have the important advantage that they give consistent and easily reproducible reactions. In our own laboratory the reagent has been prepared from the seeds of Ulex europaeus, which can readily be obtained in large quantities. This reagent has

provided the internal control needed for the reliable grouping of dried blood stains from individuals of group O and group AB. The purpose of this report is to describe our experiences with this new test.

Materials and Methods

*Anti-H Reagent.** A quantity of Ulex europaeus seeds is ground up in a pepper mill, or, after addition of saline solution, in a Waring blender using a microblade. The ground up seeds are diluted to approximately 10 times their original volume in a mixture of equal parts of normal saline solution and 1 percent sodium acid phosphate (Na_2HPO_4) solution. The mixture is allowed to extract for 24 hours in the refrigerator, suspended particles are removed by centrifugation, and the supernatant opalescent extract is passed through a Seitz filter to clarify it and to remove any bacterial contaminants. The anti-**H** reagent thus obtained is stored in the refrigerator until needed.

The anti-**H** reagent is standardized by direct titration against human red cells of all A–B–O groups, and by testing the capacity of saliva from secretors to inhibit its reaction with group O test cells. In Table 1 is shown a sample titration of such an anti-**H** reagent against human red cells of various groups. As can be seen, two different group O cells gave titers of 8 units and 16 units, respectively, or an average of about 12 units; for group A_2 cells the reagent had approximately the same titer. On the other hand, group B cells reacted to a considerably lower titer, while group A_1 and group A_1B cells gave the weakest reactions.

For absorption or inhibition tests, the reagent should be diluted so that it has a titer of not less than 6 units nor more than 12 units for group O cells. The particular reagent shown in Table 1 has been used for testing blood stains and saliva both undiluted and diluted with half its volume of saline solution; that is, at a titer of 12 units and 8 units, respectively.

Inhibition Test. The suitability of an anti-**H** reagent for testing blood stains is further controlled by using it as a reagent in inhibition tests on saliva to determine an individual's secretor status. The reason for describing these tests is that any reagent which proves suitable for inhibition tests on saliva also generally is satisfactory for grouping tests on dried blood stains.

The saliva for the test is collected in dry, wide-mouth test tubes. It is permissible to have the subject chew gum or paraffin to increase the flow of saliva. Saliva contains an enzyme which can destroy the A–B–O blood group substances. Therefore, as soon as the specimens are collected they should be placed in a boiling water bath for 10

* The prepared anti-**H** can be purchased from Certified Blood Donor Service, L. I., N. Y.

TABLE 1

Titration of Anti-**H** Reagent (Ulex Europaeus) Against Various Human Red Cells

Specimen number	Blood group	Reactions with seed extract diluted						Titer
		Undil.	1:2	1:4	1:8	1:16	1:32	
1	O	++±	++	++	+	—	—	8
2	A_2	++±	++±	++	+±	tr.	—	12
3	B	+++	+±	+	tr.	—	—	4
4	O	+++	+++	++±	++	+	—	16
5	A_1B	+	tr.	tr.	—	—	—	1
6	A_1B	tr.	—	—	—	—	—	0
7	A_1	tr.	—	—	—	—	—	0
8	A_1	+±	+±	tr.	—	—	—	3
9	A_2	+++	++±	++	+±	tr.	—	12

The strength of the reaction is indicated by the number of plus signs as follows:

+++ = one large clump
++± = several large clumps
++ = many finer clumps
+ ± = very fine clumps barely visible to the naked eye
\+ = distinct clumping but visible only under the microscope
± = clumps containing only a few cells each
tr. = trace
— = no clumping

The titer is the reciprocal of the highest dilution giving a distinct (one plus) reaction.

TABLE 2

Sample Protocol of Inhibition Tests with Anti-**H** Reagents Against Saliva —Samples from Different Individuals

Specimen number	Blood group	Secretor status	Reaction with group O cells of mixture of anti-**H** reagent and boiled saliva diluted					Inhibition titer
			Undil.	1:4	1:16	1:64	1:256	
1	O	Secretor	—	—	—	—	+±	64
2	O	Secretor	—	—	—	tr.	++	32
3	A_1	Secretor	—	—	—	++	++±	16
4	O	Nonsecretor	++	++±	++±	+++	+++	0
5	B	Nonsecretor	++	++±	++±	++±	+++	0
6	A_1	Secretor	—	—	++	++±	++±	4
7	A_1	Nonsecretor	+++	+++	+++	+++	+++	0
8	O	Secretor	—	—	tr.	++	++	8
9	A_1	Secretor	—	tr.	++	++	++±	2
10	B	Secretor	—	—	++	++±	+++	4
11	A_1B	Secretor	—	—	tr.	++	++±	8
Reference standards	Commercial solution of blood group substances		—	—	—	—	+±	64
	Nonsecretor saliva		++±	+++	+++	+++	+++	0

minutes or brought to a boil over a bunsen flame. The coagulated mucus is removed by centrifugation, and the supernatant opalescent fluid is transferred to a fresh test tube and stored in the refrigerator until tested.

A series of dilutions of the heated saliva are prepared as follows: Undiluted, 1/4, 1/16, 1/64, and 1/256. A drop of each saliva dilution is transferred to the corresponding tube of a series of five small tubes (inside diameter 7 mm. to 8 mm.). To each tube is then added one drop of the anti-**H** reagent. The mixtures are allowed to stand for 5 minutes, and then to each tube is added a 2 percent saline suspension of fresh, washed group O cells. The rack is then shaken and allowed to stand at room temperature for two hours. Each tube is then gently shaken and the reactions read with the naked eye and under the low power of the microscope. A sample protocol is shown in Table 2.

As can be seen from the table the use of anti-**H** reagents prepared from Ulex seeds makes it possible to distinguish sharply between secretors and nonsecretors. However, among secretors, inhibition titers ranging from as low as 2 units to 64 units may be obtained. In general, as to be expected, the highest inhibition titers were obtained with saliva from group O individuals, though exceptions to this rule have been encountered. It should be mentioned that tests on the same saliva sample on different days may yield different titer values, due to the differences in the sensitivity of the test cells, differences in temperature, as well as accidental differences in shaking the tubes and reading the end points. Therefore, it is best always to carry out these titrations in parallel with a reference standard, such as a commercial solution of blood group substances, or saliva from a secretor which has been stored in the freezer, and to express the results as a fraction of the titer of the reference standard, e. g., 64/64, 32/64, 16/64, 0/64, etc. All reactions are read blind, generally by a different individual from the one who set up the tests (8).

Experience has shown that anti-**H** reagents giving reactions similar to those shown in Table 2 are satisfactory for use in tests on dried blood stains.

Blood-Stained Material. Blood samples were drawn from the vein of individuals of known blood groups and placed on clean absorbent paper and cloth and allowed to dry. These were the dried stains used as controls in the test. In addition tests were carried out on blood-stained articles brought by detectives to the serological laboratory of the Office of the Chief Medical Examiner. These articles were evidence in cases of homicide, and consisted of the clothing of the deceased whose blood group had generally already been determined by testing a specimen of blood obtained at the post-mortem examination, and also blood-stained clothing of suspects, blood-stained weapons, and other blood-stained material. All the blood stains were subjected to chemical and precipitin tests to establish the presence of human blood, before any grouping tests were carried out.

Small blood-stained pieces of material approximately half an inch square were cut out, and similar small pieces of adjacent unstained material were cut out for use as controls. These pieces of stained and unstained material were placed in corresponding labelled small (inside diameter 8 mm.) test tubes. To each were added two or three drops of anti-**H** reagent, or enough to saturate thoroughly the material without leaving any excess which could run off when the tube was inverted. The sopping wet material was prodded several times with a glass rod to express the reagent and then to allow the cloth to reabsorb it. The glass rods were then removed, the tubes corked and the rack containing the tubes was placed in the refrigerator for at least 4 hours, and more often overnight. Then with a capillary pipette and bulb two drops of the anti-**H** reagent were recovered from the material in each tube by pressing down on the material while aspirating, and the recovered reagent was transferred to a corresponding well on a well slide. To each was then added one drop of a 2 percent suspension of fresh group O cells, and the well slide was placed on a shaking machine for 10 minutes, or until the control unabsorbed anti-**H** reagent showed clumping of the group O test cells, clearly visible to the naked eye. Readings were then taken with the naked eye and under the low power of the microscope. Experience has shown that the reactions with anti-**H** reagents are sharper and more readily reproducible if the tests are set up in tubes (instead of on well slides), and the mixture allowed to react for 3 or 4 hours in the refrigerator, instead of at room temperature.

All the stains were simultaneously tested with anti-**A** and anti-**B** serums suitably diluted. These tests were set up in the same way as the test just described, substituting anti-**A** or anti-**B** for the anti-**H** reagent. The anti-**A** serum recovered from the stain was tested against fresh cells of the subgroup A_2, while the anti-**B** reagent recovered from the stains was tested against a suspension of fresh group B cells.

Results

In Table 3, is shown a sample protocol of some of the results obtained by the absorption technique on dried blood stains, using anti-**A**, anti-**B** and anti-**H** reagents. As can be seen, blood stains from the known group O individuals (lines 1, 2, 3, and 10 of Table 3) failed to neutralize anti-**A** and anti-**B** reagents but did neutralize the anti-**H** reagent. On the other hand, blood stains from group A_1B individuals (lines 4 to 9) neutralized both the anti-**A** and anti-**B** but failed to neutralize the anti-**H** reagent. Thus, the anti-**H** reagent for Ulex europaeus seeds provides the internal control needed for the reliable diagnosis of the group O and group A_1B dried blood stains.

TABLE 3

Sample Protocol Showing Grouping of Dried Blood Stains by the Absorption Technique, Using Anti-**A**, Anti-**B**, and Anti-**H** Reagents

Nature of material	Source of material	Reactions of recovered reagent		
		Anti-**A** with A_2 cells	Anti-**B** with B cells	Anti-**H** with O cells
1. Blood stained paper	Blood of known individual of group O	++±	++	tr.
2. " " "		++±	++	tr.
3. Unstained paper		++±	++	++
4. Blood stained paper	Blood of known individual of group A_1B	—	—	++
5. " " "		—	—	++
6. Unstained paper		++±	++±	++
7. Blood stained paper	Blood of known individual of group A_1B	—	—	++
8. " " "		—	—	++
9. Unstained paper		++±	++±	++
10. Blood stained cloth	Blood of known individual of group O	++±	++	—
11. Blood stained shirt	Clothes of suspect (Deceased group O)	++	++	—
12. " " "		++	++	—
13. Unstained shirt		++	++	++
14. Blood stained trousers		++	++	—
15. " " "		++	++	—
16. Unstained trousers		++	++	++
17. Blood stained pillow	Homicide case (Deceased group B)	++	—	±
18. " " "		++	—	±
19. Unstained pillow		++	±	—
20. Blood stained trousers	Clothes of suspect; same case	++	—	++
21. " " "		++	—	++
22. Unstained trousers		++	++	++
23. Blood stained slip	Clothes of deceased; homicide case	—	++	++
24. " " "		—	++	++
25. Unstained slip		++	++	++

The remainder of the protocol shows some illustrative results obtained with this absorption test in three different homicide cases. In the first case (lines 11 to 16), the deceased belonged to group O, and dried human blood stains of group

O were shown to be present on the shirt and trousers of the suspect. In the second case (lines 17 to 22), the deceased belonged to group B, and while a group B reaction was obtained with a blood-stained pillow unstained areas on the pillow gave the same reactions, so it is not possible to determine whether the results were due to the blood or to sweat or a combination of the two. At any rate, the trousers of the suspect (lines 20 to 22) gave clear reactions indicating the presence of dried group B blood. In the third case (lines 23 to 25), the blood group of the deceased could not be determined from the specimen of blood obtained from the body at the post-mortem examination because of hemolysis. As shown in the table, on the other hand, tests on her blood-stained slip established her blood group as A.

Summary and Conclusions

Anti-**H** reagents are readily prepared from certain seeds, such as those of Ulex europaeus. Such reagents have proved to be useful for inhibition tests on saliva to determine an individual's secretor type. In this paper, the application of such anti-**H** reagents for grouping dried blood stains by the absorption techniques is described. The great value of such anti-**H** reagents lies in providing the internal control needed for reliable grouping of dried blood stains from group O and group A_1B individuals. The advantage of anti-**H** reagents from Ulex seeds is their ready availability, and the reproducibility of the reactions.

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Crib Deaths and Focal Fibrinoid Necrosis of the Infant Larynx*

*Marie Valdes-Dapena, M.D.,** Philadelphia, Pennsylvania*

Since September 1957, within the Office of the Medical Examiner of the City of Philadelphia, attention has been directed to the problem of the typical "crib death." By that term is meant the sudden and unexpected death of an infant —usually discovered dead in his crib—who was perfectly well prior to his demise.

In a group of 100 infant autopsies performed from September 1957 to September 1958, 41 were of this particular type. Of these, 28 were males and 13 females. This 2:1 predominance of the male is common in the experience of others working in this field (1, 2, 6). There may well be some fundamental explanation for it.

Among these 41 crib deaths, the Negro far outnumbers the white; there were 28 Negroes and 13 whites, again a 2:1 ratio. In the City of Philadelphia the ratio of white to non-white in children under 5 years of age is 10:4 so that actually the number of Negroes is four times as great in this series as the number of whites.

There is a definite curve as to age incidence among these crib deaths (Figure 1). Almost all of them lie within the span of 3 to 19 weeks.

Among these 41 autopsies there was some demonstrable pathologic process, either morphologic or toxicologic, which

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could have accounted for the death of the infants in 21 cases. Failure to discover any cause of death in many of the babies is again not unique among pathologists dealing with this type of material (1, 2, 6). Inflammation of the upper respiratory tract or the lower respiratory tract or both was considered to be responsible for the death of 15 of these children.

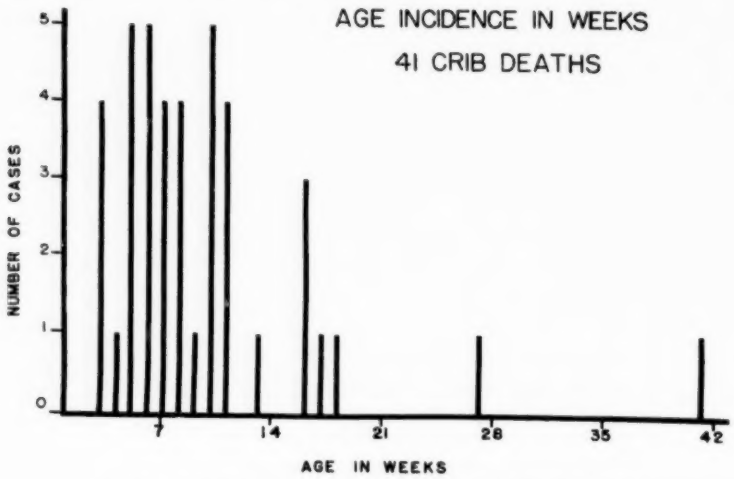

Fig. 1—Age Incidence in Weeks Among 41 Crib Deaths.

In the course of this study a peculiar microscopic lesion was noted in the larynx. It appeared in 13 of the cases. The lesion is found only in a horizontal section of the larynx taken exactly at the level of the vocal cords (Figure 2). It lies approximately half-way from the arytenoid cartilages posteriorly to the apex of the lumen of the larynx anteriorly. It is frequently bilateral.

The lesion is composed of five parts:

(1) Focal fibrinoid thickening of the basement membrane of the stratified squamous epithelial lining. (Figures 3 and 4.)

(2) Underlying, nearby focal fibrinoid necrosis of the collagenous connective tissue and in some instances the walls of the small blood vessels in that area. (Figures 5 and 6.)

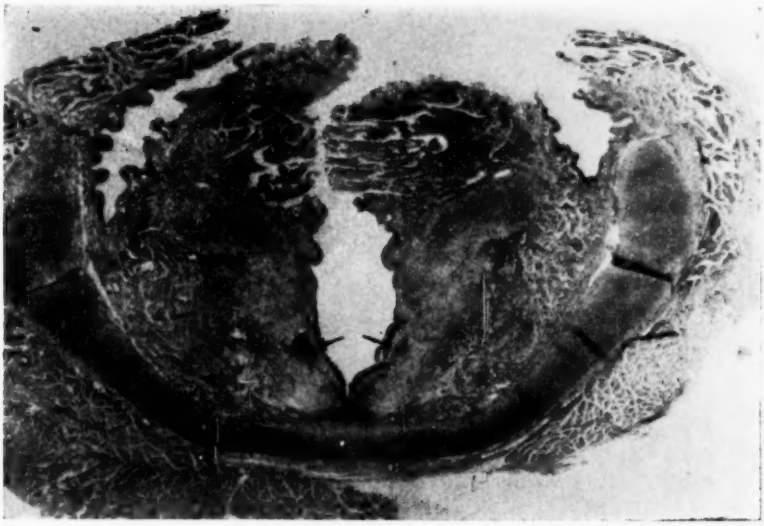

Fig. 2—Focal Fibrinoid Necrosis of the Infant Larynx. Bilateral.

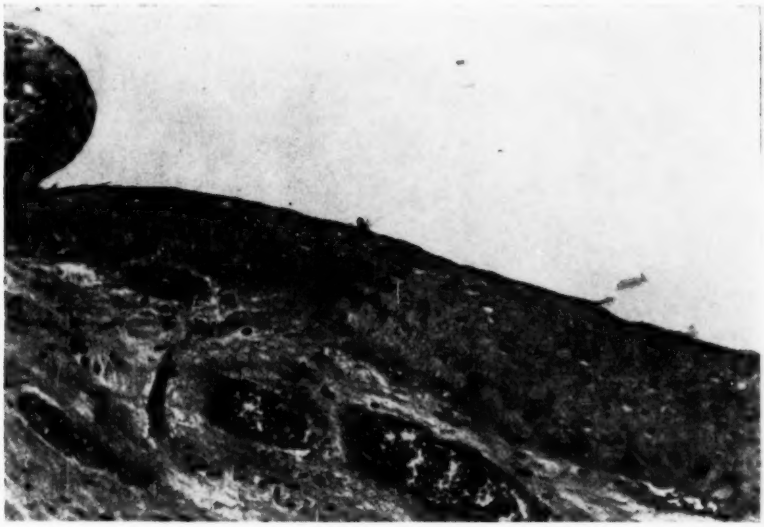

Fig. 3—Fibrinoid Thickening of the Basement Membrane.

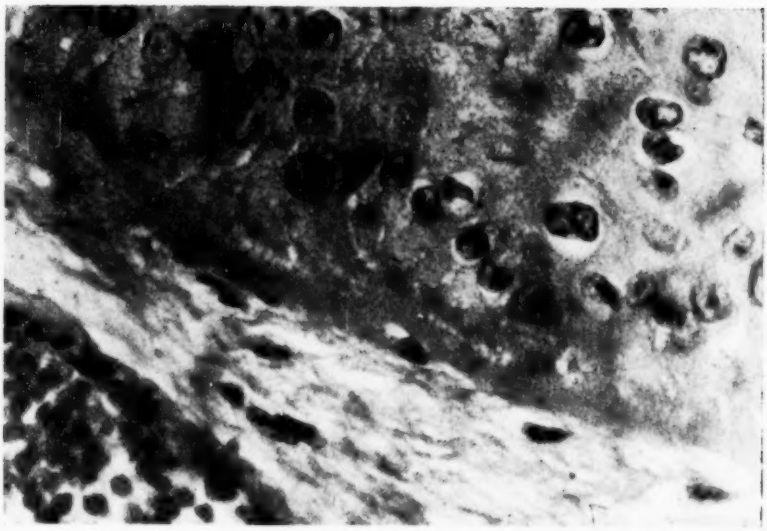

Fig. 4—Fibrinoid Thickening of the Basement Membrane, Higher Magnification.

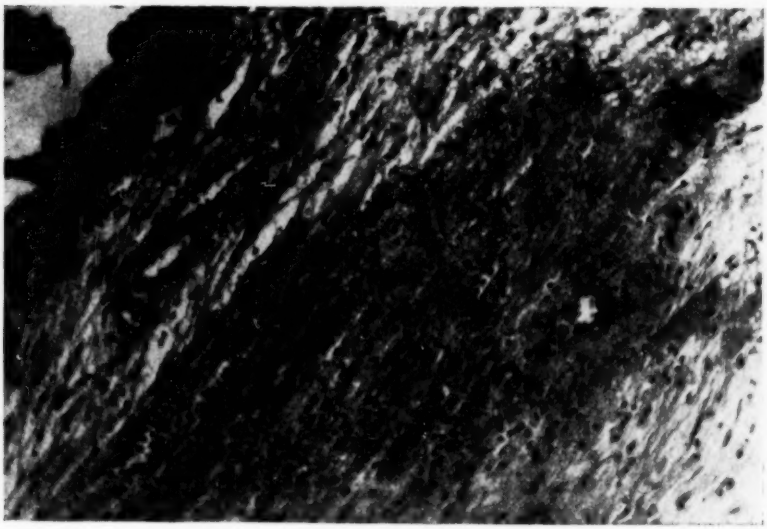

Fig. 5—A Focus of Fibrinoid Necrosis with Inflammatory Cells.

(3) Edema of neighboring connective tissue.

(4) Anitschkow "myocytes" in the connective tissue immediately about the fibrinoid necrosis and adjacent to the thickened basement membrane. (Figure 4) These cells are identical to the cells seen in the Aschoff body of rheumatic fever and the cells commonly seen in the normal infant heart (7). They are not seen in the normal infant larynx at this state of development.

(5) Inflammatory cells. These are predominantly granulocytes and they tend to cluster in and about the focal fibrinoid necrosis. (Figures 5 and 6.)

This entity has been found in a significant number of crib deaths in which there was no other demonstrable cause of death. It has not been found in any case in which there was some other obvious cause of death such as mechanical trauma, poisoning or drowning. It is occasionally associated with myocarditis and less often with the ordinary type of acute laryngitis and bronchitis.

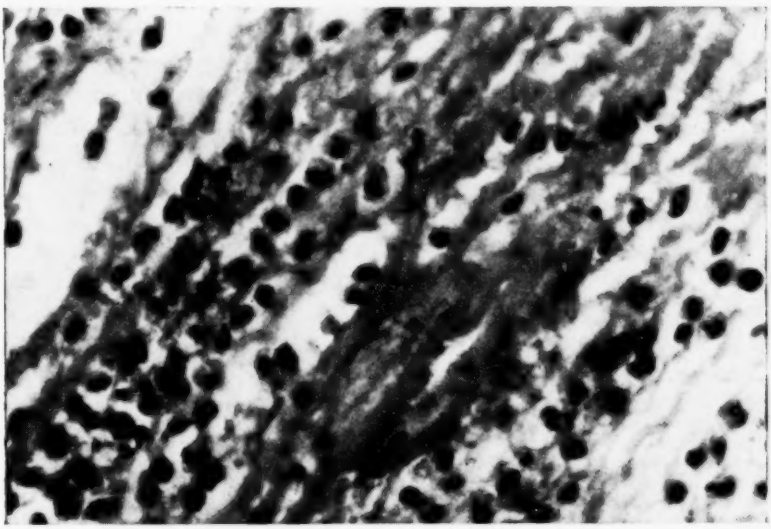

Fig. 6—Fibrinoid Necrosis and Associated Inflammatory Cells, High Magnification.

Discussion

This laryngeal lesion is similar to those produced in experimental animals by Rich (5) in his investigation of allergic reaction to the injection of foreign protein.

It is also equivalent to what is seen in connective tissue and blood vessels in collagen diseases such as rheumatic fever and polyarteritis nodosa, which are generally considered to be hypersensitive states.

There is a third close parallel and that is the likeness of this to the histologic appearance of the bronchi in asthma, another hypersensitive state. However, eosinophils are not at all prominent in these cases.

The fibrinoid necrosis of the larynx could conceivably result from the larynx serving as the target organ in an anaphylactic reaction on the part of the infant to an allergen derived either from food or from an invading organism. It is hypothesized that this reaction might be accompanied by spasm of either the larynx, or larynx, trachea and bronchi, and through viscero-visceral reflex eventuate in sudden death. This mechanism was suggested by Stowens (6) in a recent article.

After completion of my study I came across an article by Adelson and Kinney (1) in which the authors include photographs of this particular lesion. Their text mentions fibrinoid necrosis of the larynx but only as a part of acute laryngitis in which the organ is diffusely invaded by granulocytes or is the site of an ulcer of the usual variety. These authors did not attach any special significance to the fibrinoid necrosis but merely considered it part and parcel of a severe laryngitis.

Werne and Garrow (8) also reported having seen this lesion in 7 out of 31 cases but did not describe either the associated thickening of the basement membrane or the Anitschkow cells. They referred to this lesion as "laryngitis with necrosis. They believed that both "suppurative laryngitis" and "laryngitis with necrosis" could produce sudden death in infants. But like Adelson and Kinney they attached no particular significance to the fibrinoid necrosis as such.

Summary

1. Among 41 crib deaths autopsied in the space of a year for the Office of the Medical Examiner of the City of Philadelphia there were 28 males and 13 females.

2. Twenty-eight of these cases were Negro and thirteen white. Thus, as contrasted with the population of Philadelphia under 5 years of age there were 4 times as many Negroes as whites.

3. Almost all of these crib deaths occurred in infants between 1 and 5 months of age.

4. An acceptable cause of death was established in 21 of these cases.

5. In 13 cases in which no other cause of death was found, the larynx showed focal fibrinoid necrosis. It is suggested that this may be a specific histologic lesion which by some mechanism can result in sudden death.

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Histochemical Demonstration of Cholinesterase—Application to Forensic Pathology*

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In a previous report (1) we stressed the desirability of having available a method of proving that the cause of death in a given instance was due to exposure to one of the organic phosphate compounds. This group of substances, many of which are extremely toxic, is widely used as insecticides. They exert their action in the human by depressing the activity of the cholinesterase enzyme system. The importance of this family of enzymes in nerve-impulse transmission and activity at effector sites has been emphasized by many. Our previous paper pointed out one method of proving death due to poisoning by toxic organic phosphates; this method involves the determination of the post-mortem blood cholinesterase activity. A markedly depressed blood cholinesterase level would be evidence of poisoning by one of these compounds.

This paper details a second method of proof of such poisoning, based upon the histochemical demonstration of cholinesterase activity at the motor end-plate region in skeletal

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muscle. This approach has been suggested previously and preliminary work has been carried out by Bergner and coworkers (2, 3). The organic phosphate compounds combine more or less irreversibly with tissue cholinesterases. Therefore, a semi-quantitative assessment of cholinesterase activity at any one of the points of normal occurrence of the enzyme might be used as proof of poisoning. In the poisoned individual, the activity of the cholinesterase as demonstrated histochemically should be markedly less than that at a similar site in the normal individual.

The problems of importance to the forensic pathologist that must be answered before this histochemical approach can be used and properly interpretated are several:

1. Can a histochemical technique for the demonstration of the enzyme be simple and reproducible?
2. What is the most practical tissue site to use for the demonstration of the enzyme activity?
3. How long after death can the cholinesterases be demonstrated by histochemical means?
4. What is the effect of embalming and fixation on cholinesterase activity?

1. *The histochemical technique:* Several methods are available for the histochemical demonstration of cholinesterase. Koelle and Friedenwald (4) developed a suitable technique which was rendered more reproducible by Gomori (5). Modifications of their procedures have been made by Bergner (6), and we have further simplified the method. Our technique for staining true cholinesterase follows:

Solutions:

A. Stock solution (Gomori):

Copper sulfate	0.3 gram
Glycine	0.375 gram
Magnesium chloride	1.000 gram
Maleic acid	1.75 grams
N (4%) sodium hydroxide solution	30.0 ml.
40% sodium sulfate solution	170.0 ml.

This solution will keep indefinitely at 37° C. At this temperature the sodium sulfate will remain in solution.

B. Stock solution prepared for use:
Acetylthiocholine iodide [1] 0.020 gram
Dissolve in a few drops of water and then add 10 ml. of the stock solution A and filter.

C. Sodium sulfate 40% solution.

D. Sodium sulfate 20% solution.

E. Copper sulfate solution 0.1 molar.

F. Ammonium sulfide solution:
Prepared by diluting ammonium sulfide solution (light) [2] 1:18 with water. Centrifuge and filter after adding 1–2 drops of copper sulfate solution E. Solutions B and F are made up just prior to the time the tissues are to be processed.

Method:

The tissue to be stained for cholinesterase is teased apart and wrapped in lens paper with an appropriate label attached for identification. The solution B is placed in a McJunkin staining dish [3] and the tissue with its lens paper wrapping is immersed in it. Incubation is carried out at 37° C for 30 minutes. After incubation, the solution is poured off, and several changes of 40%, then 20% sodium sulfate (Solutions C and D) are carried out. The tissues are rinsed with water several times. Then solution F is added and the tissues are allowed to remain in it for 30 seconds. The tissues are rinsed in several changes of water. They may be mounted in glycerine jelly or if a permanent mounting is desired, they may be carried through increasing concentrations of alcohols and then xylene for final mounting in Permount.

This method is practical, simple, and fool-proof. Approximately one hour is required to completely process the tissue, or two hours if the tissue is to be mounted permanently.

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[1] May be procured from Bios Laboratories, Inc., 17 W. 60th Street, New York 23, New York.

[2] Light ammonium sulfide solution, J. T. Baker Chemical Co., Phillipsburg, New Jersey. Ammonium sulfide content 23.4%.

[3] These shallow glass trough-shaped dishes may be procured from A. H. Thomas and Company.

2. *Selection of tissue for examination:* Cholinesterase in all parts of the body is affected by a toxic organic phosphate when a sufficient quantity of the material is present. The most readily available tissue that contains sites of true cholinesterase concentration is skeletal muscle. In striated muscle the cholinesterase of the myoneural junction may easily be demonstrated by the histochemical method previously mentioned. The real problem lies not in the demonstration of the cholinesterase sites but in knowing where the myoneural junctions are located in a muscle fiber many centimeters in length. It is obvious that if a length of muscle containing no myoneural junctions is selected for examination, no cholinesterase activity will be demonstrated. The muscle will then be falsely considered to represent tissue without cholinesterase present, and the diagnosis of death due to organic phosphate poisoning may be entertained.

To resolve this problem a short fiber-length muscle was chosen. This is the external intercostal muscle. In this muscle, the myoneural junctions are located at approximately the midpoint of the muscle fiber. To avoid an error due to sampling the wrong segment of this short-fiber muscle, a block of muscle tissue is taken including the full length of the fibers as shown in Figure 1. The muscle is removed at autop-

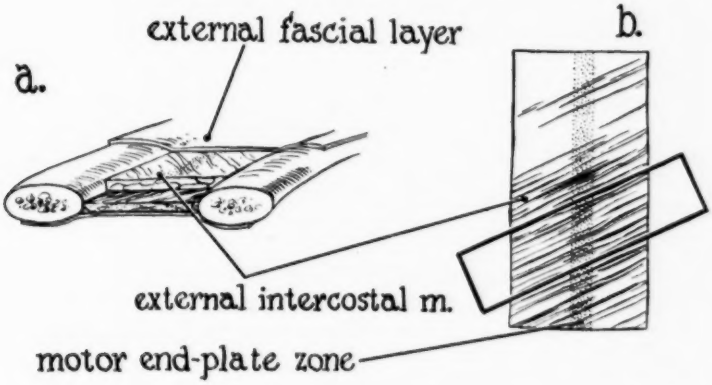

Fig. 1—Diagramatic drawing of intercostal muscle showing motor end-plate zone.

sy, stored in a clean, dry bottle without fixation, and refrigerated (or frozen although there is no real advantage in freezing) if a period of days is to elapse between the autopsy and the staining of the muscle for cholinesterase activity.

3. *Duration of cholinesterase activity after death:* That cholinesterases are extremely stable enzymes has been emphasized by us in our previous paper (1). The fact that they remain active in blood refrigerated for weeks would suggest that the cholinesterases of tissues should remain demonstrable by histochemical means for long periods after the removal of the tissues from the body.

Intercostal muscle was removed at autopsy and stored in clean, dry bottles. Some tissue was refrigerated at 4°–6° C; other muscle was kept at room temperature. At varying intervals, portions of the stored muscle were subjected to histochemical staining for cholinesterase activity. In all instances a control sample of muscle recently removed from a body at autopsy was stained simultaneously. A second control was run in the form of muscle incubated for 10 minutes in a 1×10^{-6} M solution of D.F.P. (diisopropylflurophosphate). This active anticholinesterase compound obliterates the activity of the enzyme and this proves that the staining in the muscle not treated with D.F.P. is actually due to the presence of cholinesterase.

Table 1.

Post-Mortem Duration of Cholinesterase Activity at Myoneural Junctions. Human Intercostal Muscle.

Treatment of Muscle	Duration after Death (days)
Room temperature	3
Refrigerated—4°–6° C	157
Body immersed in water	120

Our results are outlined in Table 1. Cholinesterase activity at the myoneural junction of human intercostal muscle was consistently present in tissue stored at 4°–6° C up to 157 days. In muscle kept at room temperature cholinesterase activity could be identified up to 3 days. It is obvious that the enzyme

is very stable, and may be detected histochemically even after the muscle fiber detail is lost due to autolysis. Photomicrographs appearing as Figures 2 and 3 show the motor end-plate concentration of cholinesterase in normal human intercostal muscle, and muscle that has been refrigerated for 157 days. It will be noted that the cholinesterase activity is well marked in both instances.

Fig. 2—Photomicrograph of normal human intercostal muscle stained for cholinesterase activity. The dark circular areas show concentration of cholinesterase—(x165).

4. *Effect of fixation and embalming:* Staining for cholinesterase activity following fixation with various fixatives for 24 hours or longer was carried out on human intercostal muscle. Several fixatives were used: Zenker's, Bouin's, 10% formalin with and without $CaCO_3$, 10% formalin brought to pH 7.0 with a phosphate buffer, to pH 7.0 with NaOH–HCl, cold acetone, 8% ammonium molybdate and 20% citric acid. Only with phosphate-buffered formalin and cold acetone was there cholinesterase activity remaining after 24 hours fixation. Figure 4 shows tissue fixed with cold acetone.

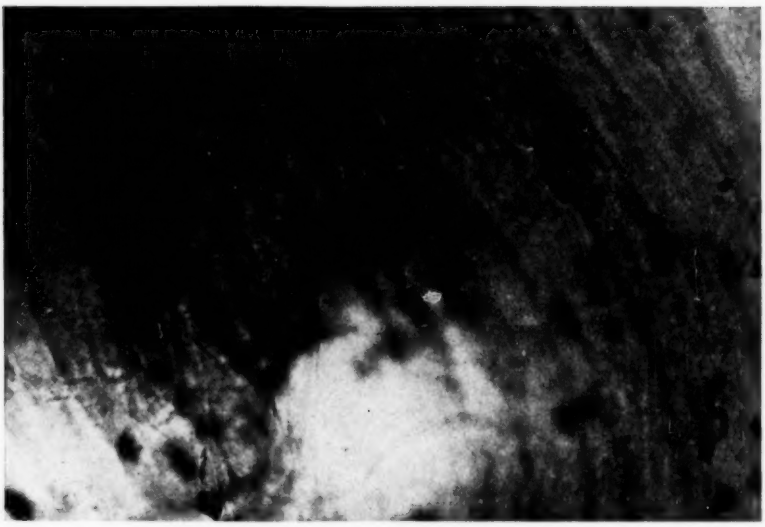

Fig. 3—Photomicrograph of normal human intercostal muscle stained for cholinesterase activity after 157 days refrigeration at 4°–6° C—(x165).

Fig. 4—Photomicrograph of normal human intercostal muscle stained for cholinesterase activity after cold acetone fixation for 120 hours—(x165).

Intercostal muscle from autopsies performed upon freshly embalmed bodies was examined in fifteen instances. The autopsy was performed within 24 hours after arterial and trochar embalming. The compositions of the embalming fluids are not known. In all cases, cholinesterase activity was present at the myoneural junctions in the intercostal muscle. The unused embalmed muscle was kept in a dry bottle at

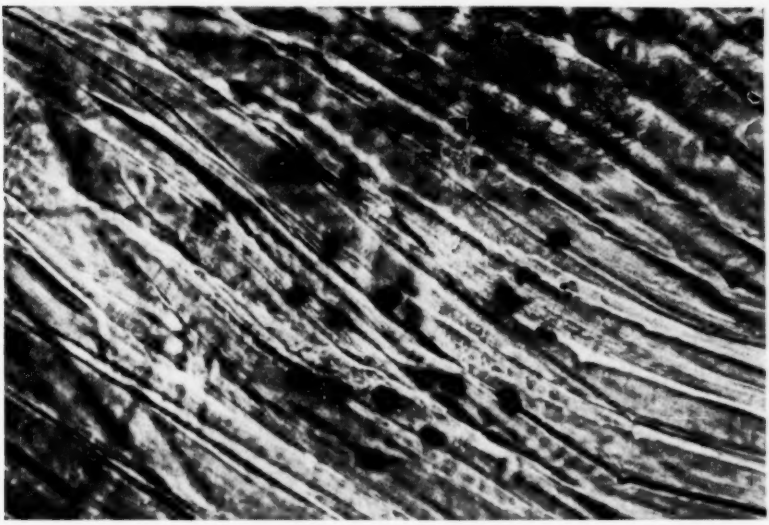

Fig. 5—Photomicrograph of normal human intercostal muscle stained for cholinesterase activity after embalming—(x165).

4°–6° C and from time to time portions were subjected to examination for cholinesterase activity. The cholinesterase remained in a demonstrable state for as long as 150 days. Figure 5 shows the appearance of embalmed muscle stained for cholinesterase activity after 12 days refrigeration. Table 2 summarizes our experience with the effect of fixation and embalming on human intercostal muscle.

Table 2.

Post-Mortem Duration of Cholinesterase Activity at Myoneural Junctions. Human Intercostal Muscle.

Fixation	Duration after Treatment
10% unbuffered formalin	< 24 hours
10% formalin and $CaCO_3$	< 24 hours
10% formalin pH 7.0 with NaOH–HCl	< 24 hours
10% formalin pH 7.0 with phosphate buffer	10 *days*
Bouin's	< 24 hours
Zenker's	< 24 hours
Cold acetone	35 *days*
8% ammonium molybdate	< 24 hours
20% citric acid	< 24 hours
Embalmed	
Composition of embalming fluids unknown	150 *days*

Discussion

The use of this histochemical method of proof of poisoning by the anticholinesterase compounds is satisfactory with fresh, refrigerated, and in some instances, embalmed intercostal muscle. This technique, coupled with the examination of the erythrocyte cholinesterase activity should suffice to prove the reason for death in the organic phosphate poisoned individual. Very probably it may be used more to rule out this type of poisoning than to prove it.

In vitro exposure of human muscle to several of the organic phosphate insecticides has been carried out. Exposure to two of the toxic members of the group, T.E.P.P.[4] and Systox [5] caused a prompt reduction or obliteration of cholinesterase activity at myoneural junctions. Figures 6 and 7 show the result of such in vitro studies. With this data available, we can expect that depletion or marked reduction in cholinesterase activity will be noted in the motor end-plate area in cases of fatal organic phosphate poisoning. As the mode of action

[4] T.E.P.P. is Tetraethylpyrophosphate.

[5] Systox is a trade name for an insecticide concentrate containing 26.2% demeton (O, O–diethyl–O–2–ethyl mercaptoethyl thiophosphate), 2.3% related organic phosphates and petroleum distillate.

Both of these compounds are organic phosphates used as insecticides.

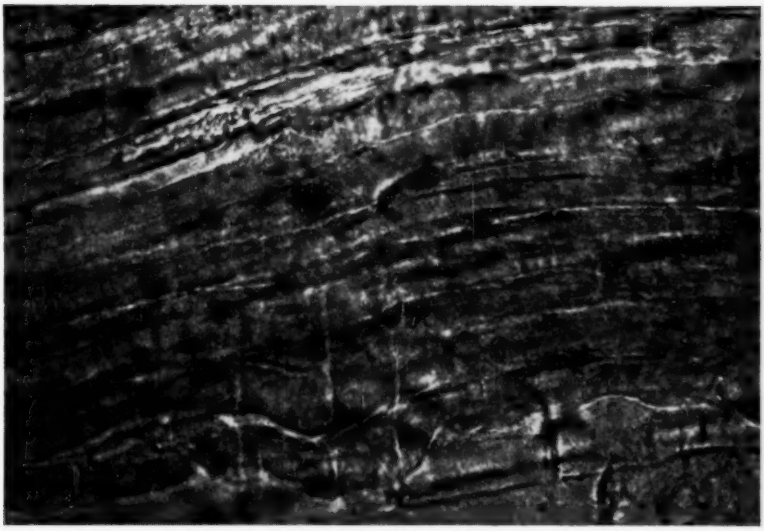

Fig. 6—Photomicrograph of normal human intercostal muscle stained for cholinesterase activity after in vitro exposure to T.E.P.P.—(x165).

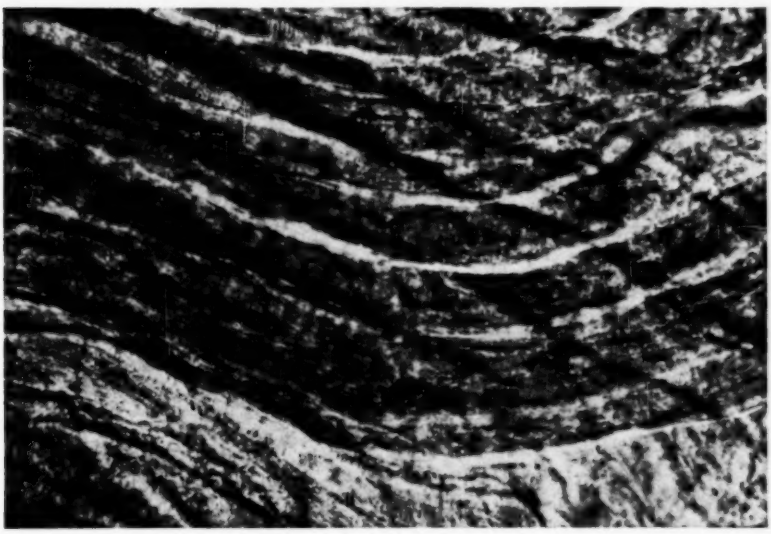

Fig. 7—Photomicrograph of normal human intercostal muscle stained for cholinesterase activity after exposure to "Systox" fumes—(x165).

of all of the toxic organic phosphate insecticides is the same, it may be assumed that all members of the group would cause a similar histochemically demonstrable depression of cholinesterase activity.

To our knowledge, suicide and fatal accidental poisoning have resulted from the more toxic members of the organic phosphate insecticide group. In this country, homicide has never been proved to have been carried out with one of these agents. The techniques for proving such a case are now available and we would term this "preventive forensic medicine."

Summary

A practical method for the histochemical demonstration of cholinesterase activity has been examined from the point of view of the forensic pathologist. The post-mortem duration of cholinesterase activity at the motor end-plate region of human intercostal muscle has been determined and the effect of embalming and fixation has been studied. The histochemical demonstration of cholinesterase activity is suggested as one means of proving death due to exposure to one of the toxic organic phosphates. In vitro studies with muscle exposed to toxic organic phosphates were shown to have depressed cholinesterase activity; these observations lend support to this method of proof of poisoning.

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Book Reviews

POLICE PERSONNEL MANAGEMENT, by A. C. Germann, Professor of Police Science, Long Beach State College, Long Beach, California. Charles C Thomas, Publisher, Springfield, Illinois, 1958, 251 pages. $6.75.

Police Personnel Management is a work on a subject of ever-increasing importance to the police administrator. Professor Germann was formerly an officer with the Los Angeles Police Department and has brought to his subject the benefit of experience gained there. His book surveys the entire field of police personnel management. It is divided into five parts: Selection, Payment, Development, Regulation, and Motivation.

In his approach the author has selected basic principles of personnel administration and applied them to the policing field. He makes no attempt to treat techniques in detail but rather to give an understanding of "what part management plays in the overall picture of police administration and what guides can be derived for evaluation."

Germann succeeds well in his aims. While experienced police officers will find much of the material to be elementary, the book as a whole is concerned with information and procedures that will be of great benefit to police officers everywhere. The principles advocated will, if followed, result in far better personnel and in more efficient enforcement of the law. On those subjects which frequently are controversial, the author's approach is objective, although he pulls no punches. He does not hesitate to give opposing views with reasonable fairness but at the same time he is unequivocal in stating the position he believes to be the better one.

Professor Germann's book is an important contribution to a field in which there is relatively little literature. It should become a standard reference for police forces. It is an excellent guide for chiefs of police and personnel officers, and can be of tremendous help in the training of administrative officers.

David A. McCandless

FORENSIC MEDICINE (Third Edition) by Keith Simpson, M.D., Reader in Forensic Medicine to the University of London at Guy's Hospital, London, 1958, pp. 352, $7.00. Edward Arnold (Publishers) Ltd., London; printed in Great Britain by Jarrold and Sons, Ltd., Norwich, and distributed in the United States by Williams and Wilkins Co., Baltimore, Maryland, exclusive United States agents.

This short text on Forensic Medicine was essentially designed to provide a brief and practical guide—from an English school—in 1946. Since then new concepts with the current law, newer experiences in the investigation of un-

natural and violent deaths, the introduction of newer synthetic drugs and its effect on the human organism, has prompted the author to revise his text and publish a third edition.

The author of this text, an outstanding teacher and investigator in Forensic Medicine, stresses the most important dogma in medicine, namely, the truth. Dr. Simpson states "Truth—or the nearest reasonable approach to it that is possible from what is observed—is the sole aim. Vagueness and theory have no place in forensic medicine, and the doctor who properly says he does not know, or feels inadequately qualified to give opinion, acquires more respect than one who guesses."

In this short text there are 28 chapters and the most essential information is given particularly for the student and neophyte interested in this subject. Apparently the question of remuneration for performing a medicolegal autopsy and testimony in courts is an important factor in Great Britain for the author devotes three chapters on this subject. This text as others in Forensic Medicine published in England stresses the English law, and includes a chapter on Medicolegal aspects of insanity. There are eleven short chapters on medical aspects in toxicology.

This text is a valuable compendium in Forensic Medicine for the medical student and the physician interested in this field. The more experienced worker and investigator in this subject will require a more detailed and elaborate discussion in the medical and toxicologic phases of this problem.

The illustrations are well chosen and mainly from the author's personal experiences. The format is good and the index is adequate. This text fulfills the author's premise as a brief and practical guide in Forensic Medicine.

S. L.

POLICE PLANNING (Second Edition) by O. W. Wilson, Dean, School of Criminology, Professor of Police Administration, University of California. Charles C Thomas, Publisher, Springfield, Illinois, 1957, 546 pages.

Police Planning, in its second edition, continues to be an excellent reference and guide for the planning staff of any police organization. It should be read and studied by supervisory and administrative personnel as well as individuals training for or aspiring to these positions. An understanding of the concepts set forth would be beneficial to police officers of all ranks.

Under fifteen chapter headings, comprising approximately half of the book (283 of the 546 pages), planning procedures and detailed discussions of many of the problems facing the police administrator are listed. The planning process is detailed and, as an example, the organization of the Planning and Research Division of the Los Angeles Police Department is included. Admittedly, all departments will not need such a comprehensive organization but the basic concepts will remain the same in most cases. The idea that the planning unit should act to stimulate planning throughout is excellent since without participation and acceptance by all members, even a good plan may not work out well.

Factors to consider in organization in accordance with functions, territory, and personnel are discussed as well as those arising in planning patrol and

detective operations, vice and delinquency control and, of course, the ever-present traffic problem. New material is included in the section on patrol and traffic control particularly with respect to the use of motorized equipment. A change in thinking is indicated by a change in nomenclature involving patrol activities. Routine patrol is now referred to as preventative patrol and the need of inspectional services receives more attention. This may be the result of the pendulum swing from foot patrol to motorized patrol and now some intermediate operation recognizing the need for basic patrol functions and yet making use of the advantages of motorized operations.

The discussions of methods for computing manpower needs and distribution are not as clear as they might be and reference to a good work on statistical methods might give a better understanding to weighing factors and rounding procedures. The author leaves the door open with the final sentence, "If the administrator or planner is not convinced of the validity of the above assumptions, he may make his own and assign weights accordingly."

No new material is included under delinquency control. There have been many changing ideas in this field recently and although the author's ideas may be sound, the planning officer might benefit from references to the various concepts now being tried throughout the country.

Auxiliary services are covered and administrative procedures described in more detail than are operational procedures and tactics. New material under reports and modus operandi is included.

A discussion of civil service practices and their relation to the control exercised by the chief points out the unique problem of selection of police personnel not facing other governmental agencies. Some of these problems have been overlooked in the rush to cure the ills of deficient police departments through civil service or merit systems. Administration of discipline and training procedures come in for slight changes under the heading of personnel and public relations.

Thirteen appendices include examples of plans, procedures and outlines. Some of these are from specific departments and others are composite in make-up. The section on basic data for planning (appendix A) is a good check list for the police administrator. Excerpts from duty manuals, recruit manuals, duties at the crime scene and plans for a large athletic event are other items included.

All in all an excellent book and while it naturally cannot provide push button solutions to "all possible requirements," as indicated on the jacket, it does provide a wealth of information on a wide variety of subjects and problems which face the police administrator at one time or another.

Constant reference to "Police Records" [1] and "Police Administration" [2] for examples and detailed explanations suggest these volumes as a desirable if not a necessary part of the planning library.

John F. Williams

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[1] Wilson, O. W., "Police Records," Public Administration Service. 1942.
[2] Wilson, O. W., "Police Administration," McGraw-Hill Book Co. 1950.

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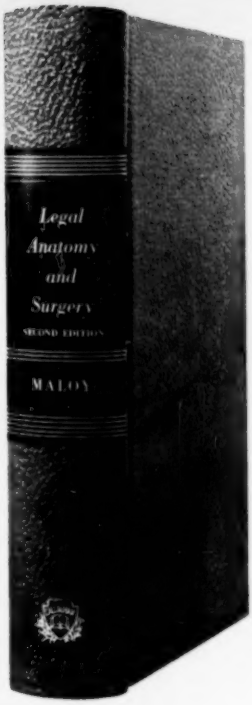

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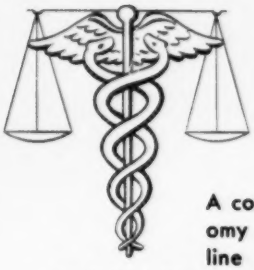

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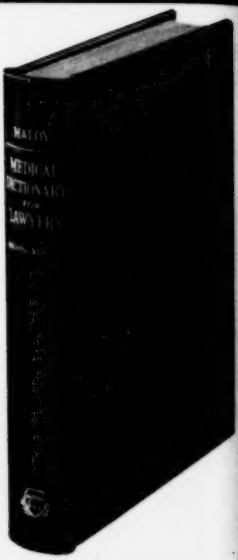

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